m Sun To Earth

SUMMER SCHOOL FOR TEACHERS

NEW · PATHWAYS · IN · SCIENCE

From Sun to Earth

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New Pathways in Science

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WE LIVE on a large moving ball. As we look out from the earth, we see many different things. We see stars, comets, shooting stars, the sun, and the moon. As we look about on our own world, we see some things which are living, such as plants and animals and other things which are not living, such as mountains, rocks, and rivers. About us are many things which have been made by man, such as plows, compasses, tractors, automobiles, and airplanes. About us are also things which we cannot see but which we know are there, such as air and heat. All these things have interested people. Men have wondered about them and have asked such questions as these:

What causes the weather?
Why do not all plants die in the winter?
How does light reach the earth from the sun?
How do birds find their way across hundreds of miles of land and sea when they are traveling?
What are our bodies like?
Are there other worlds than ours?

You too may have asked questions like these. If you read the stories in this book, you may be helped in answering your questions.

Some of the stories tell about the things that boys and girls found out by experimenting with heat, light, plants, animals, magnets, and electricity.

You may wish to try these and other experiments. Perhaps you may discover some things that the boys and girls in these stories did not discover.

From Sun to Earth

WE KNOW many ways in which the sun is helpful to us. The sun with its light and heat is necessary for living things to grow on the earth. Yet there are many things that we cannot explain about the sun's light and heat.

Some of the questions that have interested scientists for a long, long time are

What is light?
How does light travel?
How does heat travel?

Scientists know many things about light and heat, such as how sunlight makes color, how fast light travels, and why we can see through some things and cannot see through others. We can find in the story on the next pages the answers to these questions, and we can also find the best answers that scientists can make to other puzzling questions.

THE PICTURE BETWEEN PAGES 8 AND 9 IS FROM A PAINTING BY BEN STAHL.

Light

THE SUN'S ENERGY

Many races of people have worshiped the sun. The sun was so important to them that they called it a "giver of life." Though we do not worship the sun today, we depend upon it. We depend upon it because the sun is a source or storehouse of energy.

No one knows when man first discovered how to change heat energy to light energy.
It may have happened when he was striking stones together

When we have enough energy, or power, we are able to do many kinds of work. Energy which is stored up in our bodies comes from the food we eat. All animals get energy from the food they eat. Animals use plants and other animals for their food. So plant food is used by animals for energy.

Plants must have energy to grow. Their energy for growing comes from the sun in the form of light energy and heat energy. That is why we say that the sun is the source of energy.

The sun gives off this energy in all directions. It is not flat and round with light energy coming out from the edge. The sun is shaped somewhat like a ball, and energy comes out in all directions from it. It is well that we are so far away from this great source of energy. If we were much nearer, the kinds of living things that we know would probably not go on living. The earth would receive so much light and heat energy that the living things on it would die.

Some parts of our earth are uncomfortably warm as it is. Yet the earth receives only one two-billionth of all the sun's energy. One two-billionth is hard to think of. Perhaps if we write it as a fraction with figures, $\frac{1}{2,000,000,000}$, it will be easier for us. Or let us think of the work all the people on the earth could do as the whole energy of the sun. Then the work one single man could do would represent the energy the earth receives. This very small amount of the sun's energy is enough to keep living things growing on the earth.

LIGHT IS ENERGY

We say that light is a kind of energy. No one has ever been able to make energy. But the important thing is that man has learned to change one kind of energy to another kind of energy.

The first man who changed heat energy to light energy may have been very surprised. We are not sure about the way he did this. Perhaps he was striking two stones together. Perhaps he was chipping off pieces of a hard stone called flint to make arrowheads. As he worked, sparks flew from the stones. These sparks were hot. They were so hot that they set fire to some dry leaves on the ground. What had happened? Why, the heat energy caused by the striking made the leaves burn. The hot leaves gave off more and more heat energy until some of that heat energy was changed to light energy. Man had made heat and light!

Today man can change one kind of energy to another much more easily. Our match sticks have chemicals on one end. If this end is rubbed over a rough surface, such as sandpaper, heat energy causes the chemicals to change. The match burns. So man causes chemicals to change. When they change, heat and other energy is given off.

We can cause a change of energy by pressing an electric-light-switch button on the wall. When we do this, we allow electrical energy to flow through a light bulb. Some of this electrical energy changes to heat energy as it passes through the thin wires in the bulb.

Then the heat changes to light. This happens very quickly. Almost at the moment we press the wall button, the lamp is lighted. Yet these changes of energy must take place before we can use the light.

LIGHT COMES FROM THE SUN

Our light comes from the sun. Even the electricity which we use for lighting depends on the sun. We are able to have electricity today partly because the sun helped plants to grow thousands of years ago. These plants were later changed to coal. Coal is often used to heat water so that it changes into steam. Then this steam turns the wheels of machines which make electricity in powerhouses. Electric currents begin to flow. So you see that without the light energy of the sun plants could not have grown and been changed into coal, which is often necessary in making electricity for our use.

Then, too, the sun's heat causes water to evaporate from oceans, lakes, and rivers. This water vapor, which you cannot see, forms clouds that are blown about by winds. Some of the water

Have you ever thought how often you cause electrical energy to change to light energy?

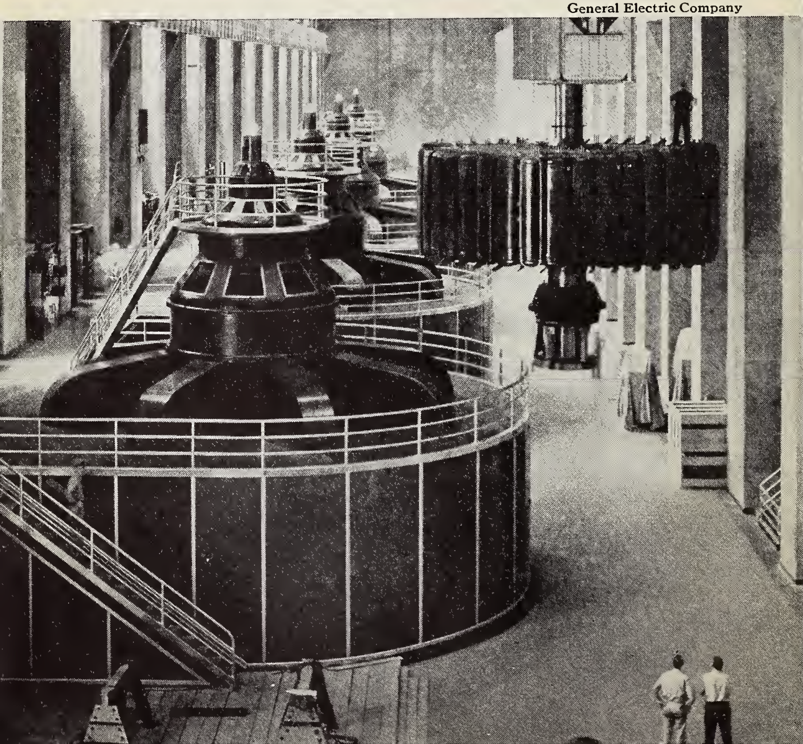
Richie

in the clouds falls back on the land and begins to rush back to the streams and oceans. Dams are sometimes built across the streams so that the water will have enough power to turn wheels. This moving water is so powerful that it turns the wheels of machines in powerhouses. Again, electric currents begin to flow.

The heat energy of burning coal and the moving energy of swiftly flowing streams cause electric currents to flow. So the sun is really the source of the electric lights which man controls.

These wheels, or turbines, in a powerhouse are turned by the energy of moving water

General Electric Company



WHAT IS LIGHT?

Scientists have been puzzled about the sun's light for many years. They have wondered how it gets to us. There is no air far out in space. So air cannot bring light to us from the sun. Scientists tell us that light travels to the earth from the sun in much the same way as radio waves travel. Radio waves on the earth do not travel through wires. Yet we know that they can travel long distances.

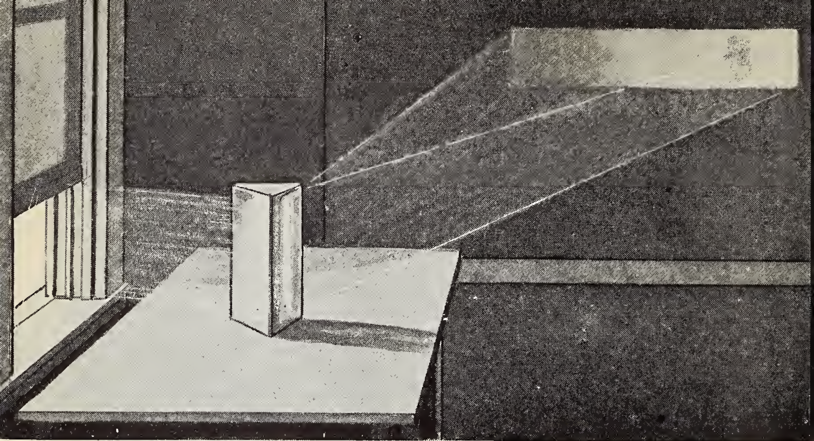
We have said that light waves are something like radio waves. They are also something like heat waves and X rays. Perhaps you wonder why we cannot see these other waves if they are like light. It so happens that our eyes are made in such a way that light waves are the only waves which make us see.

Even scientists are not sure they know what light is. They are able to make theories, that is, to say what they believe, about light. Such theories explain many things for them. But they are always looking for even better explanations.

SPEED OF LIGHT

One of the things which scientists do know about light is how fast it travels. However, we have not known this fact very long.

The famous scientist Galileo believed that light traveled at a certain speed. Galileo's experiments did not show the exact speed of light, but he did prove that light travels faster than sound.



When sunlight passes through a prism, the light is broken into different colors

You can prove this, too. All that you will need is something with which to make a noise. Two small boards will do very well. The two people who do this experiment must stand about five hundred feet apart. Let one person put a piece of board on the ground and then drop another piece on it. The other person first sees the boards hit. Then he hears a sound. The explanation is that the light from the boards reached his eyes before the sound which they made reached his ears; that is, light waves travel more quickly than sound waves.

About two hundred and fifty years ago a man named Roemer said that light travels about 186,000 miles in one second. It was hard for people to believe that light traveled at such a great speed. However, scientists were given more proof of this; for not long after Roemer told about his experiment, an English scientist also found that light traveled at about this same speed.

Since that time the speed of light has been checked many times. Scientists always get about the same thing. So we can think of light as traveling about 186,000 miles in a second.

Since we know that light travels 186,000 miles a second and that the distance to the sun is 93,000,000 miles, it is easy to tell how long it takes light to reach us from the sun. We know that it takes about eight minutes for sunlight to travel the great distance between the sun and the earth.

Do you see why it takes such a short time for light to come to your eyes from a lamp? Suppose the lamp is ten feet away from your eyes. The light from the lamp will travel the ten feet in about $\frac{1}{98.000.000}$ of a second. That is only a moment. Light travels so quickly that we do not realize that it does take a little time for it to travel so short a distance as ten feet.

It is a good thing that light goes so quickly. Would it not seem queer if light traveled only ten feet in a minute? Then we should have to wait a whole minute for light to reach us from across a room after the lamp had been lighted!

SUNLIGHT IS MADE OF DIFFERENT COLORS

Scientists have shown us many things about light. Newton was probably the first scientist who realized that sunlight was made of different colors.

Newton showed this by using a special piece of glass called a prism to break up the sun's light. He allowed the

white light from the sun to pass through a prism which he held up. By doing this, he found on the wall a band of colors, which he called a spectrum. The glass had separated the colors. The sun's spectrum has the following colors in it: red, orange, yellow, green, blue, and violet. You also can experiment with a prism to break the sun's light into a spectrum. Perhaps you have noticed that your aquarium sometimes acts like a prism. Have you ever seen a band of colors made on the floor or wall by the water in the aquarium?

Sometimes little water drops in the sky act as a prism. Light passing through the mass of water drops is also broken into a band of colors. We call this spectrum a rainbow.

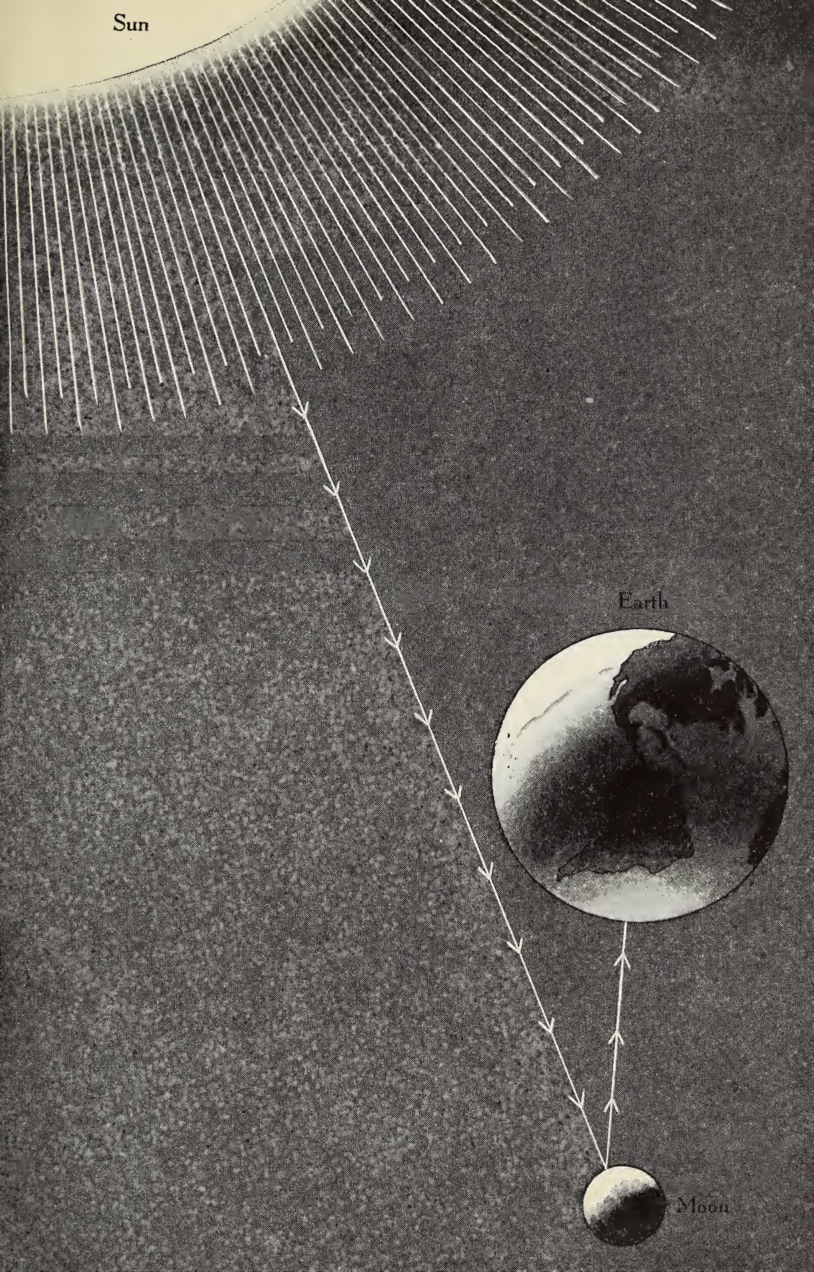
So white sunlight is really made of the light waves of different colors put together in just the right way. Scientists are sure about that.

REFLECTED LIGHT

Many objects give off light waves. The sun does. So do other stars, electric lights, candles, matches, bonfires, and many other things. When the light waves from these objects strike our eyes, we see. Such objects are sources of light.

But how is it that we are able to see our hands, feet, trees, houses, furniture, people? These things do not give off light of their own.

You can experiment with some of these things. Go into a very, very dark closet. Make sure that no light


Sun
Earth
Moon

comes through the keyhole or from under the door. Hold your hand before your eyes. Can you see your hand? Can you see the walls of the closet? Now turn on a flashlight. You can see the walls of the closet, your hands, your feet, and anything else in the closet.

We say that things which light falls on reflect light. To reflect light means to turn light back to you. A mirror reflects light very well. Hold a mirror so that the sunlight falls on it. Can you make light dance about the room? The light waves strike the mirror and are turned back again.

A mirror reflects so well that you should not look directly at it when the sun shines on it. You feel uncomfortable if too much reflected light enters your eye. That is why we should be careful not to read out of doors in the bright sunlight. The white paper of the book reflects too much light to your eyes.

The moon also reflects sunlight very well. It acts like a giant mirror. The sun shines on the moon and this light is reflected to the earth. Does the picture on page 19 help you to understand this?

Our faces reflect light into other people's eyes. We see our hands because they reflect light. All objects which we see either give off their own light or reflect light to our eyes.

COLORS

We proved that sunlight is really made up of several different colors; that is, that these together make the bright sunlight. When any light strikes a white object,

all the light is reflected to our eyes. This means that the waves of the spectrum are turned back at the same time. We call all these colors together white light. When we see all the light of the sun, we see white light.

But what gives red, blue, green, or yellow objects the color which they have? Green leaves reflect only part of the white light waves. The one part that is reflected is green light. Since only the green light is reflected by a green leaf, the leaf looks green to us.

A red dress reflects only red light. A blue shirt reflects only blue light.

You can prove that a red dress reflects only red light and a blue shirt reflects blue light. Get some pieces of red, blue, and green cellophane. Double the pieces and hold them before a strong light. You should have a clear red light when you use the red cellophane and a clear blue or clear green light when you use the blue or green cellophane.

The rest of this experiment should be done in a very dark room. Choose a girl who has on a bright red dress. Hold the red cellophane directly in front of a flashlight. The light from the flashlight is now red, and the girl's dress looks very red because the dye in the dress reflects red light to your eyes. Now hold the blue cellophane in front of the flashlight, causing blue light to shine on the red dress. Is it still red? If your cellophane is a clear, good color, you will notice that the red dress is now very dark, almost black. This fact is easy to explain. The dye in the dress will reflect only

red light. No red light now falls on the dress. So it looks dark or black because very little light is reflected to your eyes. Try the green cellophane. What happens?

You might like to try the same experiment with a boy who is wearing a blue shirt. Does his shirt look blue only when the blue or white light shines on it?

Now try a black coat with the lights. You would expect it to be black with any of the colored lights. Black reflects very little light. It absorbs, or takes in, almost all the light. That is why we say black is an absence of light.

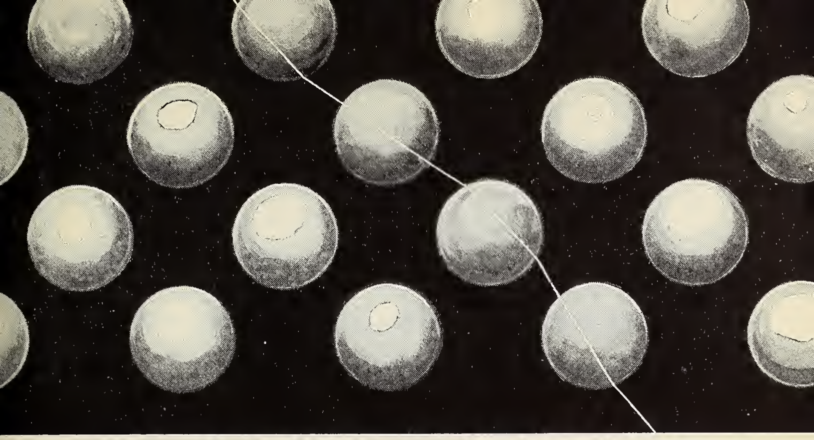
White objects are very different from black ones because white things reflect all light. If you shine red light on a white dress, the dress appears to be red. If the dress is under green light, it appears to be green.

People who light theaters know the effect of lights on different colors. They often use light gray curtains on the stage. Light gray reflects almost all the light which falls on it. So the curtains look blue if blue lights shine on them. They seem to be yellow when yellow light shines on them.

Actors and actresses also think of these things when they plan their costumes for a play.

COLOR OF THE SKY

Light is reflected from many, many objects. It is reflected from raindrops, from tall buildings, from grass, and from tiny particles, or bits of dust, in the air which you cannot see.



A ray of light is bent as it passes through water droplets

We cannot see through a cloud, but some of the sun's light does pass through it. The light is sent from one little drop of water to another. So some of the light finally gets through the cloud and reaches our eyes.

The picture above shows one ray of sunlight which is bent back and forth as it passes through a cloud. You can see that it does not pass directly through the cloud.

Now all the particles of dust and water in the atmosphere, or air around the earth, help to scatter sunlight about. Even on a clear day sunlight is scattered about a great deal. We know this because the sky is very blue. Blue light waves are the shortest light waves we know about. They can be reflected and bent about more easily. On a clear day most of the sunlight comes directly to us. But the short blue light waves are reflected from one particle in the air to another until the whole sky looks blue.

When there are many, many dust and water particles in the air, all the light waves are scattered. They are reflected in many directions. This makes the sky look gray-blue. Have you ever noticed that the sky is this color before a storm?

LIGHT WAVES PASS THROUGH SOME THINGS

We have been saying that light waves are like radio waves and X rays. Yet they are very different too.

Radio waves pass right through the walls of buildings. They travel through metal. X rays can go through a person's skin and muscle but not through his bones. Light waves cannot do this.

Light waves can pass directly through some things. We can see clearly through clear glass, the air, and clean water. These things are transparent.

Sometimes light passes through objects but does not pass directly through them. It is bent about on its way through them. You remember we said this sort of thing happened in a cloud. Light passes through painted glass in this same manner. We say that such objects are translucent. That is, light is able to pass through some objects, but not directly through them. Because of this we cannot see clearly through things which are translucent; yet light does pass through them.

There are many objects through which light cannot pass at all. It cannot go through bricks, wood, people, and many other things. These are called opaque ob-

jects. Opaque objects make shadows and darkness. If the earth were not opaque, it might always be day. Light would go right through the earth, and there would be day all the time and on all parts of the earth.

If our eyelids were not almost opaque, we should have much trouble in resting our eyes. We should have no shade at all during the day. Perhaps it is just as well that light waves are different from X rays. It would be a queer world if light waves could pass through all things so that we could see through all things.

THINGS TO THINK ABOUT

1. What do you think would happen if light could not be reflected? Could you see the person sitting next to you? Could you see anything in the room? Could you see the sun?

2. Do you think you would be very comfortable if the earth were much nearer the sun?

3. Sunlight helps to prevent and cure many diseases. Sunlight is necessary for the proper growth of our bodies. Do you see why we should spend much time out of doors?

THINGS TO DO

1. Perhaps you could help with stage lighting at your next school play. A lantern for slides, or pictures on glass, makes a good spotlight. You could make slides of colored cellophane for your colored lights. The actors' clothes will reflect only certain colors. Remember this when you are planning your lighting effects.

2. Plants use energy from the sun in making food. Leave a plant in the window for several days. Why do you think the leaves are all turned toward the sun?

Heat

HEAT AND LIGHT WAVES ARE ALIKE

Heat waves and light waves are really the same kind of wave. Our eyes are so made that we can see light waves but not heat waves. We feel heat waves.

We have said that some things give off light waves. They also give off heat waves. You can prove this for yourself. Hold your hand near an electric light. Does it give off heat? You know that a match gives off both heat and light energy. Some sources of light give off more heat than others. Name as many things as you can which give off both light and heat.

However, all hot objects do not give off light waves. A stove gives off much heat. It gives off light only if it becomes red hot. The iron with which your mother presses clothes gives off heat. Does it give off light too? We say that things must be heated red hot before they give off light. So objects which are not very hot are not "light-givers."

HEAT REALLY COMES FROM THE SUN

Heat energy comes from the sun just as surely as light does. You can prove this for yourself very easily. Hang one thermometer outside in the sun. Hang another in the shade. Read the temperature of each. Let them stay for about fifteen minutes. Now which thermometer is warmer? The sun, then, is a great source of heat energy.

Scientists tell us that it is really cold out in the great space between us and the sun. Yet we have said that heat energy comes from the sun. Both these things are quite true.

We are told that this energy from the sun must hit something before we can say that there is heat. Energy from the sun strikes us and makes us warm. It strikes dust and water in the air and makes the air warm. It strikes the thermometer and makes it warm. But, so far as we know, there is nothing in the great space between the sun and the earth to be warmed. Empty space is cold.

Man does not have to depend directly on the sun for warmth. He has learned to change other kinds of energy into heat energy. Electrical energy is changed in your toaster to heat energy. The heat then toasts your bread. Chemical energy is used in coal and wood to make heat energy. Can you think of other ways in which man has learned to use heat energy?

But even though man can use energy, he cannot make energy. Where does the electrical energy which is changed into heat energy come from? Can man make any of this energy? You remember we said that the sun is necessary to make coal. The heat energy of the sun also causes water to evaporate and form clouds. This water falls on the tops of mountains. It then flows downward in swiftly moving streams. The coal and running water help to make electricity. So the heat energy which man controls really comes from the sun. No wonder people worshiped the sun!

So far as we know, heat waves travel in the same way that light waves travel. The sun gives off a great amount of heat energy in all directions. The earth receives only a very, very small part of this heat energy. It is a good thing that this is true. If the earth received only a little more of the sun's heat energy, many strange things might happen.

The snow fields in the polar regions might melt. Many of the plants would wither and die. More water would evaporate from the ocean each day. The sky would be full of huge clouds. What a strange earth this would be!

THE ATMOSPHERE AND HEAT

But this would also be a strange earth if there were no atmosphere. Our atmosphere acts as a blanket around the earth. Now just how does this blanket of air affect the heat of the earth?

As you know, anything which is heated will give off some heat into the air. Here is an experiment which you can try, to show that this is true. Heat some water until it reaches 120°F. Now turn the heat off. Leave your thermometer in the pan. Watch the thermometer. Heat is being lost; so the temperature becomes lower and lower. Leave the water for about a half hour. What is the temperature now? Much of the heat of the water goes off into the air.

Read your room thermometer. Does the thermometer in the water show the same temperature as the room

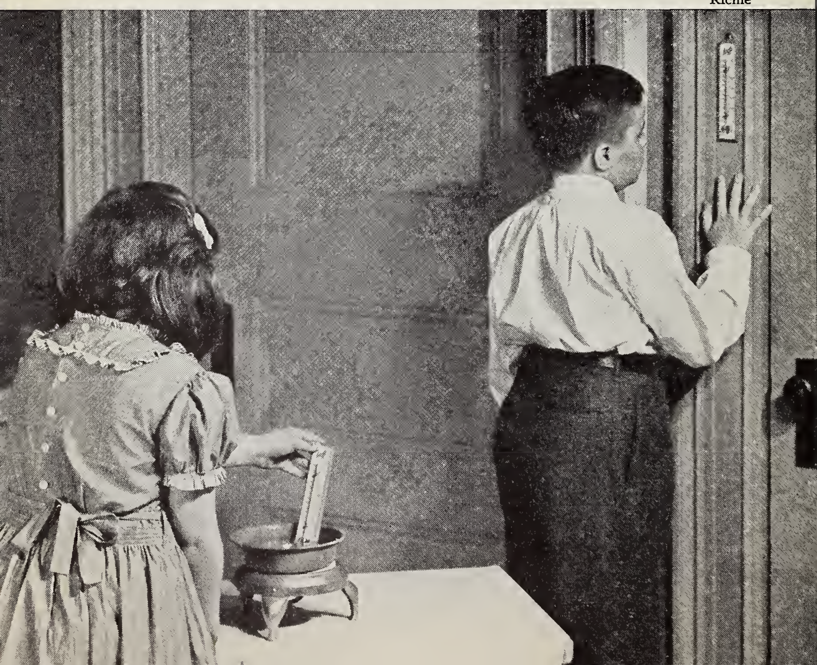
Our sun gives out light in all directions.
Only a small part of its light reaches the earth

thermometer? The temperature of the water in the pan will finally be the same as that of the room, because the water loses its heat to the air.

The same thing is true of the earth. The earth is heated by the sun. Heat is given off by the earth in all directions. But there is an atmosphere around the earth which keeps most of the heat close to the earth. If there were no atmosphere, the side of the earth turned away from the sun would be very, very cold. This means that night on the earth would be much colder than it is now.

Experiments should be done carefully, so that mistakes will not be made. It is a good idea to check your work

Richie



WHY IT IS COLD ON MOUNTAINTOPS

Some people think the tops of mountains should be very warm. They think this because mountaintops are nearer to the sun than any other part of the earth. Yet the tops of mountains are cold. Just why is this so?

We are told that the sun's rays do not warm the air very much. Most of the heat energy passes right through the atmosphere to the surface of the earth and warms the earth itself. Of course we live in this atmosphere. If the air around us is warm, we feel warm; if it is cold, we feel cold.

If the sun itself does not warm the atmosphere very much, just what does happen? We said that the earth absorbs the sun's heat energy. So it does. But when the earth becomes warm it gives off heat just as a warm stove does. So the air above the earth's surface is warmed mostly by the heat from the earth.

The warmest places of the earth are those where there is much air to be warmed. The places where the air is most dense, or thick, on the earth's surface are the low places. The farther we go up from the low surface, the thinner the air becomes. The air is therefore thinner, or less dense, on mountaintops. But the thinner air does not easily hold the earth's heat. So we feel cool on the tops of mountains even though we are nearer the sun.

HEAT TRAVELS THROUGH THE AIR

We know that heat travels through the air. We can sit across the room from a radiator and become warm. Heat travels from the radiator to us in two ways. All the air in a room does not become warm at one time. First, the air around the radiator becomes warm and is pushed up. Then more and more air in the room is warmed. Finally, the whole room is warm.

But heat may come straight to us without a movement of the air. Scientists are not sure about the way in which heat travels straight through the air. They tell us that the air is made up of tiny, tiny particles which are so small that you cannot see them even with a microscope. These particles are called molecules.

These molecules move around and around one another all the time even in still air. When air is warmed, the molecules move faster and faster around one another. So when the air around the radiator touches the radiator, the air molecules begin to move faster. Then these air molecules bump against the air molecules next to them and make them move faster. Then we say the air has become warm.

So the movement of the molecules spreads from one part of the air to another, and we say that heat is spreading in the air. This is the way the scientists explain how the air becomes warmer even though the air molecules stay in just about the same places they were in.

HEAT TRAVELS THROUGH WATER

All the water in a pan will become hot if you leave the pan on a stove long enough. Just how does this happen? You know that only a small part of the water is right over the flame. How does the top of the water get hot?

Heat travels through water in much the same way as it travels through air. First the water nearest the flame is warmed. This moves upward. Cold water takes its place and becomes warm. Finally, the whole pan of water is hot.

Here is an experiment which will show you that heated water moves about. It is best to use a glass dish for this. Fill the dish with water. Put a little sawdust in the water and let it settle down to the bottom.

Now heat the water. Try not to move the pan when you do this. Watch the sawdust. Does it begin to move about?

You can see that all the water will become warm if you heat it long enough.

Heat also travels directly through water just as it does through the air.

HEAT TRAVELS THROUGH METAL

Have you tried to toast marshmallows on a thin piece of metal? Then you know that heat travels through metal. This can be proved in another way too. You will need a long piece of metal and some paraffin. Stick

small pieces of the paraffin to the metal rod. Hold the rod so that one end is in a flame.

Watch carefully. Which piece of paraffin melts first? Then which piece falls off? Do all the pieces melt and fall? Can you explain this?

Scientists are not sure about the way in which heat travels through metal. The parts of the metal cannot move as those of air and water do. Here is one explanation that is given us. The molecules of metal near the flame become hot. They pass heat on to the next molecules. This happens all the way along the metal bar. Finally, the whole bar becomes hot.

If you take the flame away, the bar will cool. When anything cools, it gives up its heat to the air around it. The air and the iron will finally be about the same temperature, and you can touch the metal without being burned.

HEAT TRAVELS QUICKLY THROUGH SOME THINGS

Does your mother use a spoon with a wooden handle to stir cooking food? Have you ever thought about why she does this? Perhaps this experiment will help you to answer your question.

Get a wooden spoon, a tin spoon, and an aluminum spoon. If you can get a silver spoon, use that too. All the spoons should be just about the same length. Put some water in a saucepan. Now put all the spoons in the pan. Heat the water in the pan. Hold the handles

of two spoons in one hand, and hold the other two handles in the other hand. Which gets hot first?

Some children who did this experiment found that the aluminum spoon was first to get hot. They found that the wooden spoon was the last to be heated. Is this what happened in your experiment?

The heat was passed along by the molecules of aluminum very quickly. This same thing happens in many metals. We say that metals are conductors, or carriers, of heat.

Wood is not a very good conductor of heat. We use wooden roofs on our houses instead of metal roofs because of this. If we used metal roofs the sun's heat would go through the roof very quickly and warm the house. This would be quite uncomfortable in the summer.

The two pieces of paraffin near the lower end of the rod have fallen off. Can you tell why?

Richie

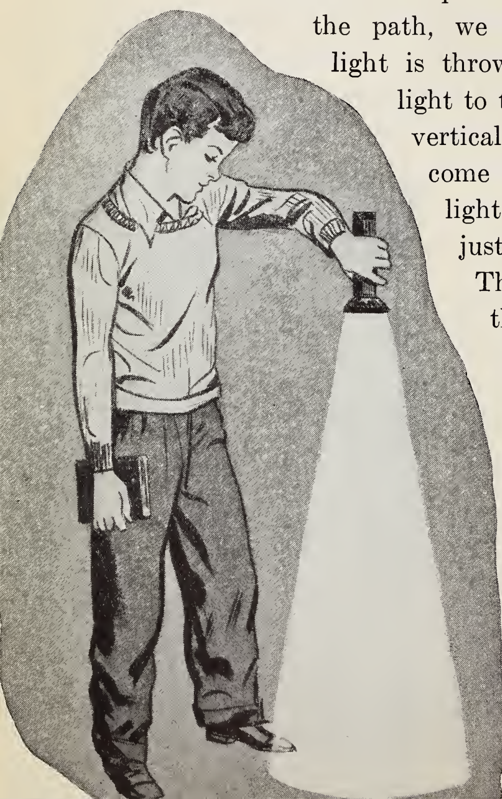
Radiators are made of iron, which conducts heat quickly. Our cooking pans are usually made of metals so that foods can be heated easily.

We are lucky to have good heat conductors. It would be very hard to heat our homes or cook our foods if this were not true.

VERTICAL AND SLANTING RAYS OF LIGHT AND HEAT

Many of us use a flashlight to find our way outdoors on a dark night. We always hold the flashlight so that the light is thrown ahead, to light as much of the path as possible. If we want to see something very clearly, we hold the flashlight so that the light falls on that thing.

When the flashlight is held in a slanting position, we say it is throwing slanting rays of light to the earth. When it is pointed straight down on the path, we say that the flashlight is throwing vertical rays of light to the earth. Now these vertical and slanting rays come from the same flashlight. One kind of ray is just as bright as the other. The only difference is that at one time the light is striking the ground in a slanting way and at the other time in a vertical

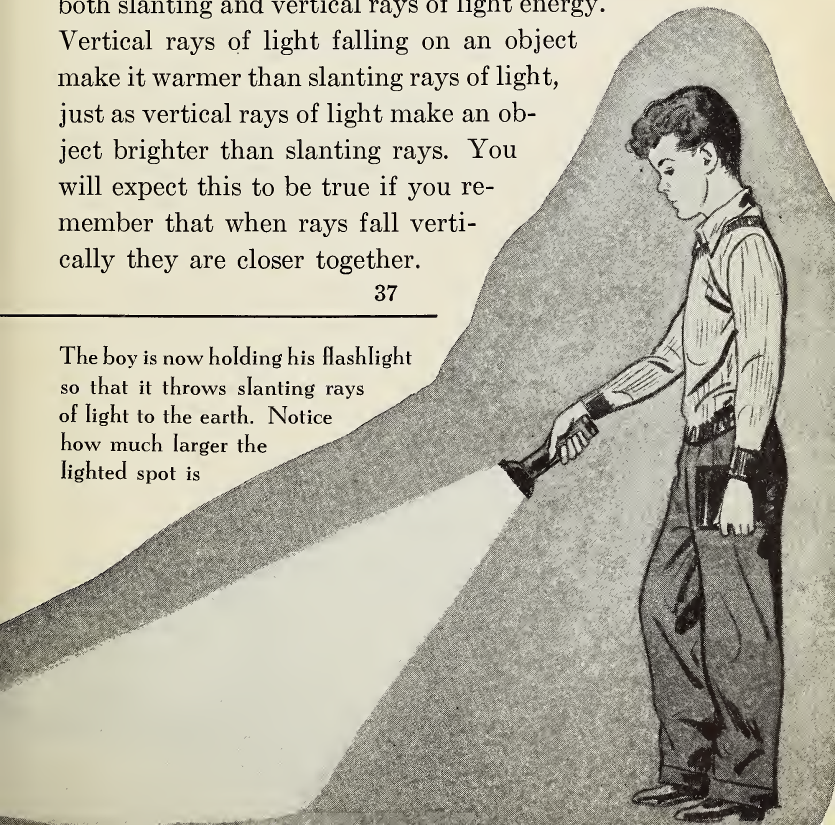


This boy is holding his flashlight so that it throws vertical rays of light to the earth. Notice the size of the lighted spot

way. The rays of light cover more space when they come to the ground in a slanting manner, so that they are spread out more. But the rays make a small place very bright when they strike that place in a vertical manner, because they are closer together.

So we see that vertical rays of light energy make things brighter than slanting rays.

You know that when an object is touched by light, some of the light energy is changed to heat energy. So the object becomes warmer. This, of course, is true of both slanting and vertical rays of light energy. Vertical rays of light falling on an object make it warmer than slanting rays of light, just as vertical rays of light make an object brighter than slanting rays. You will expect this to be true if you remember that when rays fall vertically they are closer together.



The boy is now holding his flashlight so that it throws slanting rays of light to the earth. Notice how much larger the lighted spot is

So we can see that anything which is lighted by vertical rays of light energy will be much brighter and warmer than if it were lighted by slanting rays of light.

This is just as true of the earth lighted by the sun as it is true of the path lighted by the flashlight. Sometimes the sun's rays fall nearly vertically on the part of the earth where we live. At that time days are long and warm. At other times the earth is in such a position that the sun's rays reach it in a slanting way. Then the days are much shorter and colder.

THINGS TO THINK ABOUT

1. We think that it is quite hot when the thermometer goes up to 100° F. Would it not be strange if everything which was heated to that temperature could give off light waves? Just think! Boiling water would give off light, some buildings might give off light, dust in the air might give off light. Everything would be so bright that we would probably have to wear *very* dark glasses to be comfortable.

2. We say that things melt when they change from solids to liquids. What do you think would happen if everything melted at 32° F. as ice does? Think of the many things which are now solid that would then be liquid. Tall buildings and bridges would melt and run away. Big machines in factories would spill all over the floor. Can you see why it is a good thing for us that some solids melt at a very low temperature and some at a very high temperature?

3. Think of the many ways that you use light and heat energy every day. Remember that we cannot really make any of this energy. What should we do without the sun?

THINGS TO DO

1. Have you thought about why we wear light-colored clothes in the summer? Perhaps this experiment will help you to understand why we do this. Fill two jars about half full of water. These jars should be the same size. Wrap a piece of white cotton cloth around one jar and a black cotton cloth around the other. Find the temperature of the water in each jar. Now put the jars in the bright sunlight. If the sunlight is shining down into the jars, cover the top of the jars with cloth. Leave them in the sun for an hour or so. Then find the temperature of the water in each jar. Which has absorbed more heat energy? Which has reflected more heat energy?

2. Some things boil at a higher temperature than others. Heat a pan of water till it boils. Does your thermometer read about 212° F.? Now heat a pan of very salty water until it boils. What does the thermometer read now?

II

Seasonal Change

SEASONS CHANGE

WHY DO SEASONS CHANGE?

SEASONAL CHANGE AND PLANTS

SEASONAL CHANGE AND ANIMALS

MANY changes take place on the earth. Summer is a season of warmth that changes into winter, which in some parts of the world is a season of cold. In other parts of the world, winter is a dry season, which changes into a very wet summer season. In some places both winter and summer are very cold.

Yet, all over the earth seasons do change. No matter where you live, in North America, South America, or Europe, you will find the seasons changing.

This story may help you to understand why the seasons change. The reason for seasonal change is the same all over the world even though the seasons themselves may be quite different in different parts of the world.

The living things on the earth are greatly affected by seasonal change. The picture of the life cycle of the monarch butterfly shows some changes that take place in the life of the butterfly as the seasons change.

Perhaps you can think of some ways in which man and other animals prepare for winter. What happens to them as spring comes near?

Now we shall see how man and other living things are affected by the changing seasons.

THE PICTURE FACING PAGE 40 IS FROM A PAINTING BY ELSE BOSTELMANN.

Seasons Change

Our seasons change during the year. We do not always have summer. We do not always have winter. Neither do we always have the seasons spring and autumn. First we have one season; then we have another.

This does not mean that the seasons change in the same way all over the world. In most parts of North America there are four seasons. During the winter, in many places, snow is on the ground; but the snow melts in the spring. In the summer the air is warm, while autumn brings cool winds and light snows.

In the southern part of North America we do not really find these four seasons. You might say that these places have two seasons, summer and winter. The spring and autumn seasons are not so long as they are in the northern part of North America.

But the reason for the change in seasons is the same in all parts of the world. There is winter in Russia for the same reason that there is winter in Canada. Australia has spring for the same reason that England has.

Why Do Seasons Change?

TEMPERATURES IN SUMMER AND WINTER

In many places summer and winter days are usually different in temperature. In winter the days are colder than they are in summer. On a winter day in Juneau, Alaska, it may be $-40°$ F. At the same time it may be 70°F. in San Francisco, 30°F. in Montreal, and 45°F. in New York City; while in the city of Mexico the temperature may be 60°F. However, each place is having its winter season.

The summer temperatures in these places will be much higher. It may be 65°F. in Juneau, 85°F. in San Francisco, 75°F. in Montreal, 80°F. in New York City, and 70°F. in the city of Mexico. All these places are having summer.

You see we have described summer and winter as seasons of hotness and coldness. So heat must have something to do with the seasons.

HEAT DURING THE DAY AND NIGHT

We have said that heat energy comes from the sun. We know that the sun's heat can warm the earth.

It takes the earth twenty-four hours to turn once on its axis. We call this period of twenty-four hours a day. As the earth turns on its axis, one half of it is turned toward the sun. The other half is turned away from the sun. The part turned toward the sun is lighted. The part turned away from the sun is not lighted.

The daytime at one place on the earth is much warmer than the nighttime in that same place. So, during a winter day in New York City you may find these temperatures:

3:00 in the afternoon	. . .	28° F.
3:00 in the morning	. . .	14° F.

This means that the temperature has changed fourteen degrees in twelve hours.

Let us see why this is so. By three in the afternoon the sun has been shining on the city about eight hours; so it has become warmer. At three in the morning the sun has not been shining on New York City for about eleven hours; so it has become colder.

As the earth turns on its axis, parts of it receive heat for a while. Then for a time those parts are in darkness. At any one place on the earth, more heat is received from the sun during daylight hours than during darkness. Of course this affects that part of the earth greatly. We say it is usually warmer during the day than it is during the night.

DAY AND NIGHT ARE NOT ALWAYS OF EQUAL LENGTH

Spring and summer days are longer than spring and summer nights. Day and night on our earth are not always of equal length. Perhaps this has something to do with the change in seasons.

When the days grow longer, we say that spring is coming. New leaves grow on the trees. Many animals

appear that we have not seen all winter. The weather grows warmer very slowly.

We know that the long summer days are warm. We receive much heat energy from the sun. The warm summer days are longer than the summer nights.

During the autumn the days grow shorter. Many birds fly to warmer places on the earth. Some plants die. Other plants and animals begin to live on the food they have stored during the summer.

In the winter the days are short. During the cold winter the part of the earth where we live is turned toward the sun for a shorter time each day than it is in the summer. The days during this season are shorter than the nights. So we receive less heat energy from the sun during the short winter days.

The length of day and night changes during the year. As this happens, seasons change from summer to autumn to winter to spring.

A PLAN FOR AN EXPERIMENT

Should you like to know why the days are short in winter and long in summer? Then perhaps you might like to try this experiment.

Draw on the floor a circle with a diameter of about five feet. Put a bright light in the center of this circle. You may use a very strong flashlight or three or four candles for the light. The bright light represents the sun, of course.

Now place four small earth globes on the circle. Put

the globes at the north, south, east, and west parts of the circle. Leave equal distances between the globes. The north pole of each globe should point toward the north. Each globe represents the earth at four different times during the year: spring, summer, fall, and winter. Does this picture help you to set up your experiment?

THE EARTH IS NOT ALWAYS THE SAME DISTANCE FROM THE SUN

You remember that the earth is about ninety-three million miles from the sun. We cannot show this great distance in our experiment. In the picture the four globes are the same distance from the sun. However, the path of the earth around the sun is not an exact circle. Because of this the earth is really about three million miles nearer the sun in December than it is in June. We do not notice this difference in nearness because we are so very far away from the sun all the time. In North America December days are winter days.

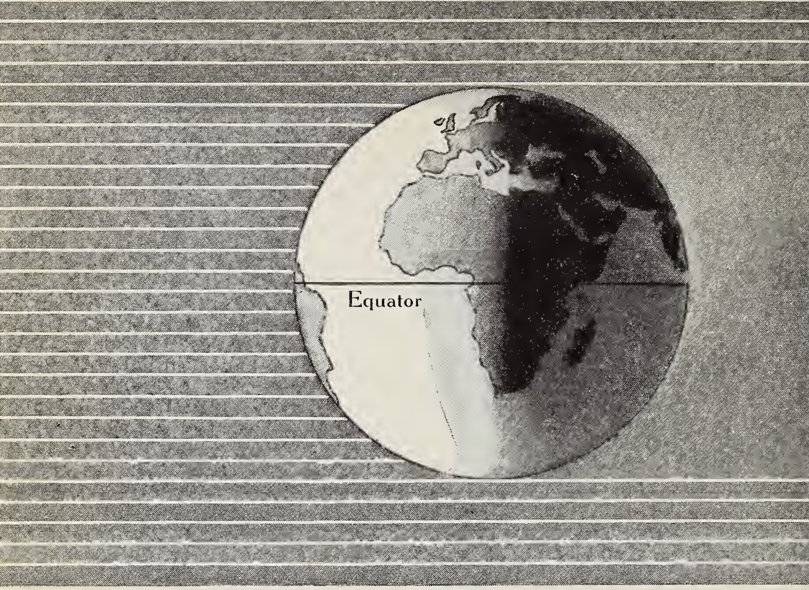
Now we know that the distance between the earth and the sun does not cause the change in seasons. If it did, the winter months would be our warmest months because North America is nearer the sun at that time.

THE EARTH IS TILTED ON ITS AXIS

Let us look for another reason for our short winter days and our long summer days. You will see in the picture that the north pole of each globe points in the same direction. No matter what day of the year it is,

Richie

The letters stand for summer, fall, and winter. Notice that the north pole of the earth always points in the same direction



In the spring, on March 21, light from the sun shines directly on the equator. Then every place on the earth has a day and a night of equal length

the north pole always points in the same direction. It is pointing in the direction of the North, or Pole, Star.

This means that the earth is tilted on its axis.

Look at the picture and think of a line from the "sun" to the center of each globe. These lines represent rays of the sun's light. Perhaps you remember that we said that light which falls directly on anything makes that thing bright and warm. In fact, we said that light which falls directly on something makes it warmer than light which falls on it in a slanting way.

Now during September and March the rays of the sun shine almost directly on the equator. For this reason it is very hot at the equator.

If you will look at the globe representing spring, you will notice that only half of it is lighted. Half of it is dark. Find the place where you live. Turn the globe on its axis. Is the night longer than the day? Is the length of the day the same as that of the night? You see the days and nights are of equal length at this time of year.

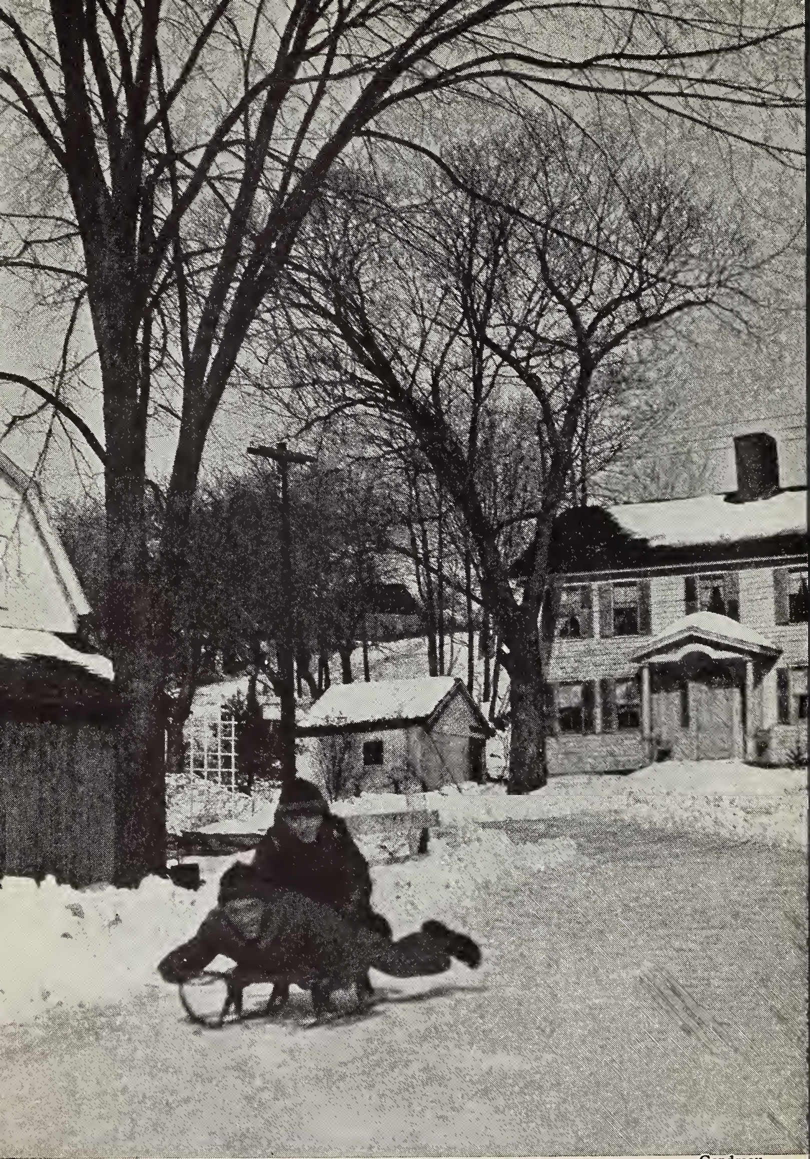
We said that in March the rays of the sun fall almost directly on the equator. Do you see what this means? It means that a city in South America a thousand miles south of the equator would receive the same amount of heat energy from the sun as a city in North America the same distance from the equator. The two cities would also have days of the same length on this day of the year.

By the end of September the earth has traveled to the opposite side of the sun. Again the sun's rays shine directly on the equator. Again days and nights are of the same length.

SUMMER AND WINTER IN NORTH AMERICA

But what happens when summer begins? During June the rays of the sun are shining almost directly on the Tropic of Cancer. The north pole now has a very long day. In fact, the sun shines at the north pole for many days without setting. Do you see why this happens?

Spin the globe which is marked with "S." Find North America. Is the day longer than the night at this time? You see that it is. This means that the sun shines on North America for more than twelve of the



Gendreau

This is December in the northern United States.

Is winter like this where you live?

twenty-four hours. Then the heat from the sun is coming more directly to the part of the world north of the equator. We call these summer days. North America, Europe, and Asia are all having summer.

Now can you tell what happens during December in North America? The night is longer than the day. Look at the north pole. During most of the winter very little heat and light reaches it, because the north pole is not tilted toward the sun but away from it.

You see that the direct rays of the sun now shine south of the equator. This means that North America does not receive so much heat as it did during the summer or fall. The winter days are the coldest of the year for that reason.

WINTER AND SUMMER IN SOUTH AMERICA

Have you ever thought about winter and summer in South America? There the winter season begins in June. At this time the sun's rays shine on South America in a slanting way, so that places south of the equator are cooler.

Look at the globe representing June again. Do you see that the south pole receives no light or heat energy from the sun? All the countries south of the equator are having winter.

Now what happens during December? Take a look at the south pole now. Is it receiving heat and light energy from the sun? You see that the earth is in such a position now that the direct rays of the sun strike the

Tropic of Capricorn. This means that the days after December will be the warmest of the year for the Southern Hemisphere. All the countries south of the equator are now having summer.

Is it not a strange thing to think that these countries celebrate Christmas at the warmest time of their year? People south of the equator wear their summer clothes while we wear our winter clothes.

ALL PLACES HAVE SEASONAL CHANGE

Perhaps you now see why the whole world has seasonal change. There is a change in the length of day. There is a difference between the temperature of the summer and winter days.

The reason why changes take place is because the earth is always tilted toward the North Star as it travels about the sun. So at certain times part of the earth receives a great deal of heat energy. When this happens, that part of the earth is having summer. At times part of the earth receives much less heat and light energy. Then that part of the earth has winter.

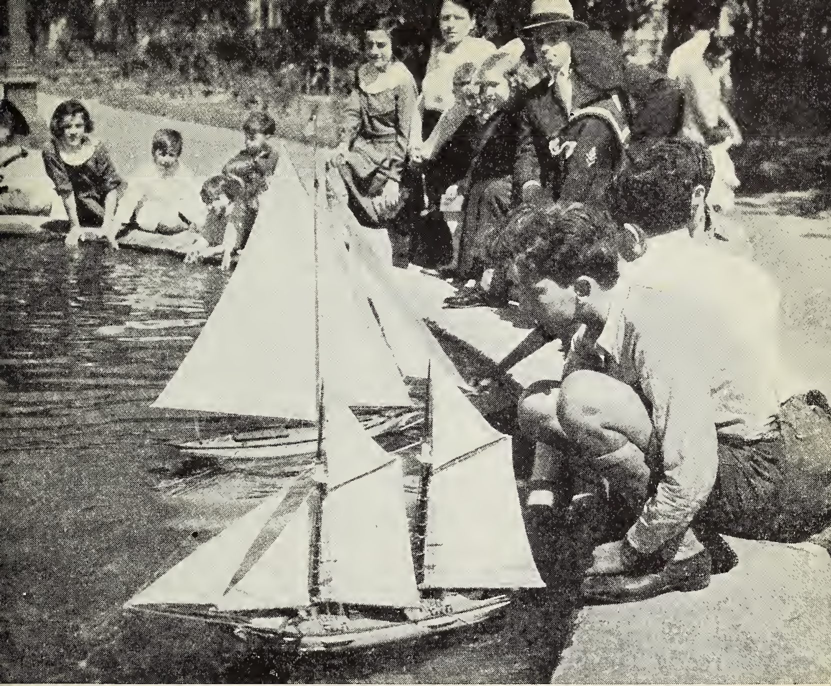
Seasons may not be the same length all over the earth. But all places all over the earth do have some kind of seasonal change.

THINGS TO THINK ABOUT

1. Does the sun send out slanting rays at one time of the year and vertical rays at another time?

or

Does the earth's position so change during the year that



Galloway

This is December in Argentina. December, January, and February are warm months in Argentina

the sun's rays fall on it as vertical or slanting rays at different times?

2. Which part of the earth do you think receives the most light and heat energy from the sun? Why?

THINGS TO DO

1. Notice where the sun is at noon in summer. Notice where it is at noon in winter.

2. As the days grow longer in the spring, notice where the sun rises and where it sets.

Seasonal Change and Plants

LIGHT AND PLANTS

Plants change all through the year. However, we notice changes most in the spring and autumn. The different amounts of light and heat energy during the year affect plants. This is because plants must have a certain amount of heat and light before they can grow.

You would expect plants to grow more in the spring and summer. There is then more light and heat. We find that this is the time of the year during which plants grow tallest. They grow many leaves. Some of them have flowers.

As short days and cool weather come, we find that there are fewer plants in bloom. Many plants have already bloomed. Seeds are blown about through the air. The grasses turn brown. Some trees lose their leaves.

Plants, then, seem to be greatly affected by the four seasons. In the spring they begin to show signs of growth. During the summer they grow tall and have many leaves and flowers. As autumn comes, food is stored in the plant. The winter months are the months in which plants rest.

PLANTS STORE FOOD

Some plants die as winter comes. Every leaf, every stem, every root on them dies. We pull these dead plants up from our gardens and burn them. The farmer plows his dead corn and cotton plants under so that the dead

plants are covered with soil. This helps to make the soil richer.

Yet the next spring there are always more of these plants. This is because those plants which die produce, or make, seeds. They store food around a small plant in the seed. This small plant is well protected and can live over the winter. When it is put in the ground in the spring it grows into a new plant.

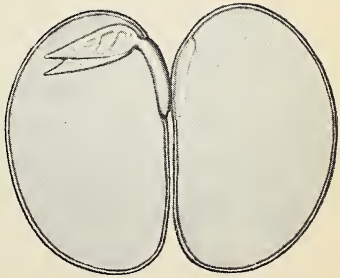
If you would like to see one of these small plants, try this experiment. Cut through a lima-bean seed the long way. Do you see the small plant in one end of the seed? All the rest of the seed is stored food. The small bean plant in the seed is able to live over the cold winter months.

Now some plants just die down to the ground as cool weather comes. Every leaf and stem on them dies. But their roots still live in the soil. There is food stored in the roots for the next year.

Carrots, turnips, and parsnips are plants in which food is stored in the roots, so that they live during the winter. In the spring new plants grow from these roots.

The white, or Irish, potato is a kind of underground stem. We call it a tuber. The "eyes" in the potato are buds for the new plant. A farmer cuts potatoes into pieces when he plants them. He cuts them in such a way that each piece

Most of a lima-bean seed is food for the small plant



has one or two eyes. The new plant lives on the food stored in the potato until it can make its own food.

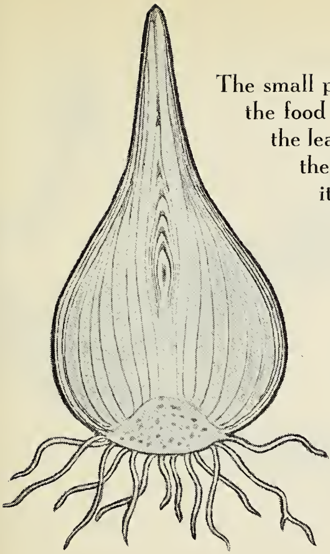
Do you know what a bulb is? If you have ever eaten an onion, you have eaten a bulb. Have you ever planted tulips or hyacinths? You did not plant seeds, did you? No, you planted bulbs.

The onion bulb you ate and the tulip bulbs you planted are storehouses of food. They are really stems that grow underground. Food which the plants make during the warm summer months is stored in the bulbs. These bulbs do not die during the winter. In the spring the plants begin to grow. For a while they live on the food in the bulb. Later they make their own food.

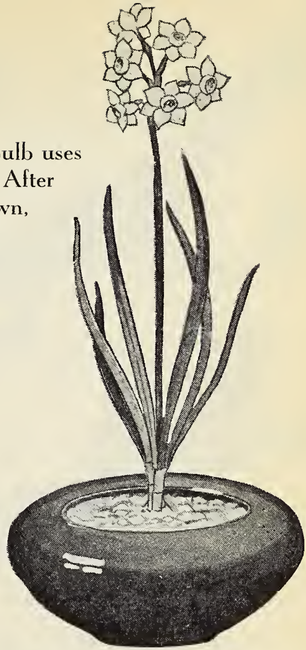
If you would like to see one of these small plants within a bulb, get an onion or some other bulb. Cut through the bulb from the place the leaves come to the roots. Do you see the small plant in the center of the bulb? Around it you find layers of stored food.

Trees store food in still another way. In the autumn after the leaves have fallen, look at the twigs and branches of a tree. You will find little buds there for the next year. These buds are formed on the branches before the leaves fall. This means that they were forming during the summer.

A great many people think that buds are formed only in the spring, but this is not true. The tree is making buds while it is making food in the summer. Some of the food that is made is stored in these buds. The little stems and leaves, and sometimes the flowers for the next year, are folded inside the tiny buds.



The small plant in this bulb uses
the food in the bulb. After
the leaves have grown,
the plant makes
its own food

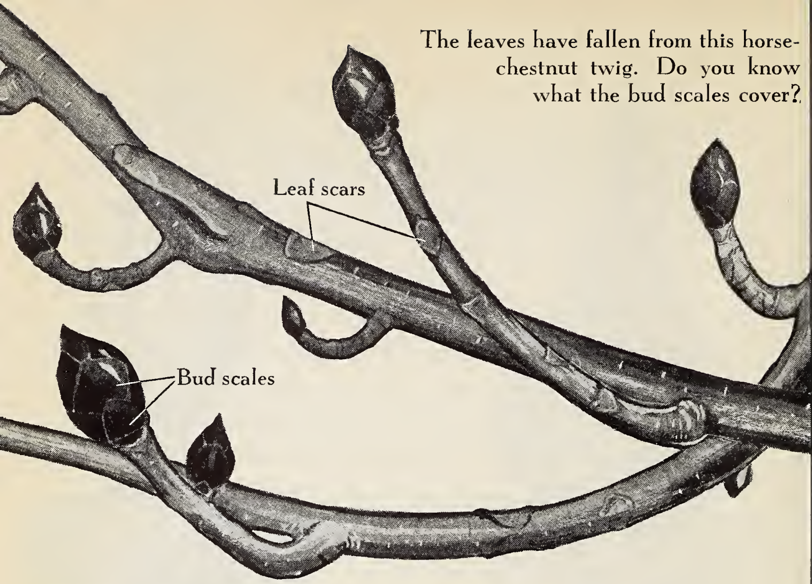


Some buds, such as those of the horse chestnut, have a hairy or cottony lining. There is a sticky cover on the outside. This lining and sticky stuff protects them from strong, cold winds. It also prevents moisture from leaving the buds.

So during the summer and autumn plants store food so that there may be new plants or further growth of old plants the following spring.

WHY LEAVES FALL

In the autumn as you travel along the highways or through the woods, you notice the brilliant color of leaves. These colors are lovely for a short time. Then



The leaves have fallen from this horse-chestnut twig. Do you know what the bud scales cover?

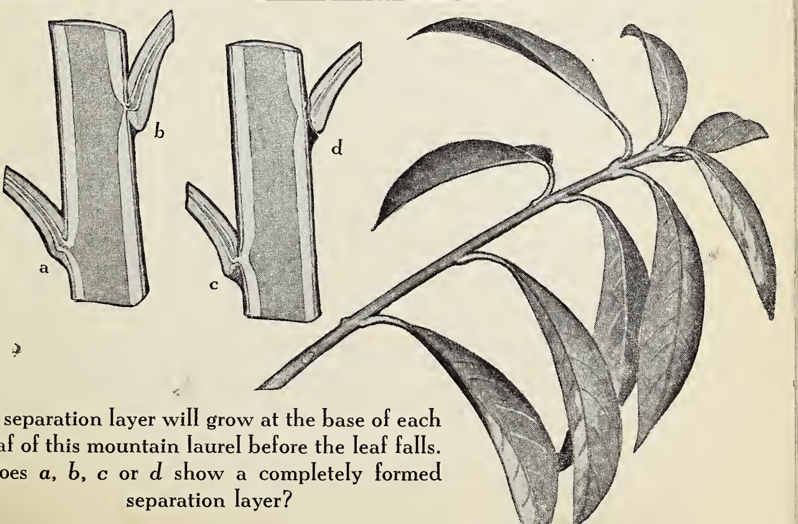
the leaves are gone. The trees which lose their leaves are called deciduous trees. Evergreens are not deciduous trees, for they do not lose their leaves at a certain time of the year.

Trees cannot grow in winter. They do most of their growing in the spring and early summer. By the middle of summer the trees have reached their full yearly growth. Then changes begin to take place in the tree.

There is less sap flowing through the trunks. Many leaves are covered with dust. Many have been eaten by insects. The leaves make very little food. Early autumn comes. When the leaves begin to change in color, their work is about ended. The food made by the leaves is stored in different parts of the tree. The leaves are almost ready to fall.

Now what happens? First, a kind of thin skin, called a separation layer, begins to grow. It grows between the stem of the leaf and the branch on which it is growing. Sometimes this separation layer is like a thin piece of cork. After it is completed the leaf falls. Did you ever try to break a green leaf from a tree? It was not such an easy thing to do. You had to pull hard. But after the separation layer has been made, the gentlest breeze makes the leaf fall. Even the weight of dewdrops often causes the leaf to fall.

When you cut yourself, you have an open wound. You must be very careful of this wound. You must see that nothing harmful gets into it, and you should even put something on the wound to kill the germs. Sometimes you cover it with a bandage. When the leaf falls from the branch, there is no open wound. Nothing harmful can get into it. The separation layer covers and protects the place from which the leaf fell. There



A separation layer will grow at the base of each leaf of this mountain laurel before the leaf falls. Does *a*, *b*, *c* or *d* show a completely formed separation layer?

Orne

If you have ever walked on pine needles like these,
you know that evergreen trees lose their leave

is nothing but a scar left. Look for these leaf scars after the leaves fall in the autumn.

Brown leaves of oaks often hang on the trees all winter. When spring comes they are still there. No wind seems strong enough to make them drop. Their separation layers are not perfectly formed. So the leaves stay on the trees. They may even stay after new ones come.

Many people believe that the leaves fall because of frost. This is not true. An early frost often delays the

fall of leaves. The separation layer is not made so quickly when there is an early frost.

Evergreen trees always have most of their leaves. They do not lose all of them in the fall. But there is a certain change for winter even in these trees. The green color of the leaves is not the same in winter as it is in summer.

THINGS TO THINK ABOUT

1. Do plants stop growing everywhere in winter? Do you suppose that plants stop growing in the tropics during part of the year? Why *do* plants stop growing?

2. You remember that some places have dry winter seasons and rainy summer seasons. Do you think plants would grow better in the winter or in the summer in such places?

3. Why do farmers have to wait until danger of frost is past before they plant their crops?

4. Is it not a good thing that plants store food in their roots, stems, leaves, and fruits? What should we do if plants did not store food?

THINGS TO DO

1. Watch the trees near your school as winter comes. Which lose their leaves first? Do any leaves stay on the trees all winter?

2. Watch the trees from week to week during the spring and summer to see when buds begin to form.

3. Plant about twelve onion sets in good rich earth which has plenty of dead leaves in it. Pull one up every week. Do you find that more and more food is being stored in the bulb? Where is this food which is stored made? What finally happens to the leaves?

Lynwood Chace

This Cecropia moth is laying eggs on the flower of a lady's-slipper

Seasonal Change and Animals

BUTTERFLIES AND MOTHS

Some animals move about part of the year and rest part of the year. Some are very much like plants in the way that they grow. They really begin to grow in the spring. During the summer they reach their full growth. They lay eggs in the late summer or autumn. Then they die.

Many of our insects, such as butterflies, moths, praying mantes, and walking sticks have such lives. It seems that the amount of heat and light energy from the sun also affects their lives.

The brightly colored butterflies and moths begin life as eggs. During the summer the mother butterfly lays her eggs on the young, tender leaves of a plant. Each kind of butterfly or moth usually lays its egg on a certain kind of plant. The monarch butterfly lays her eggs only on the milkweed plant.

Some butterflies lay a few eggs in one place and a few in another. Some lay one egg in one place and one in another. Others lay them in masses in one place. The mother butterfly or moth takes no care of her young. After the eggs are laid, she flies away.

In a few days the eggs hatch. Some young caterpillars first eat the shells of the eggs. Then they feed on the leaves of the plant. Their bodies are long and slender and are covered by a thin skin. Some caterpillars are green in color. All of them have three pairs

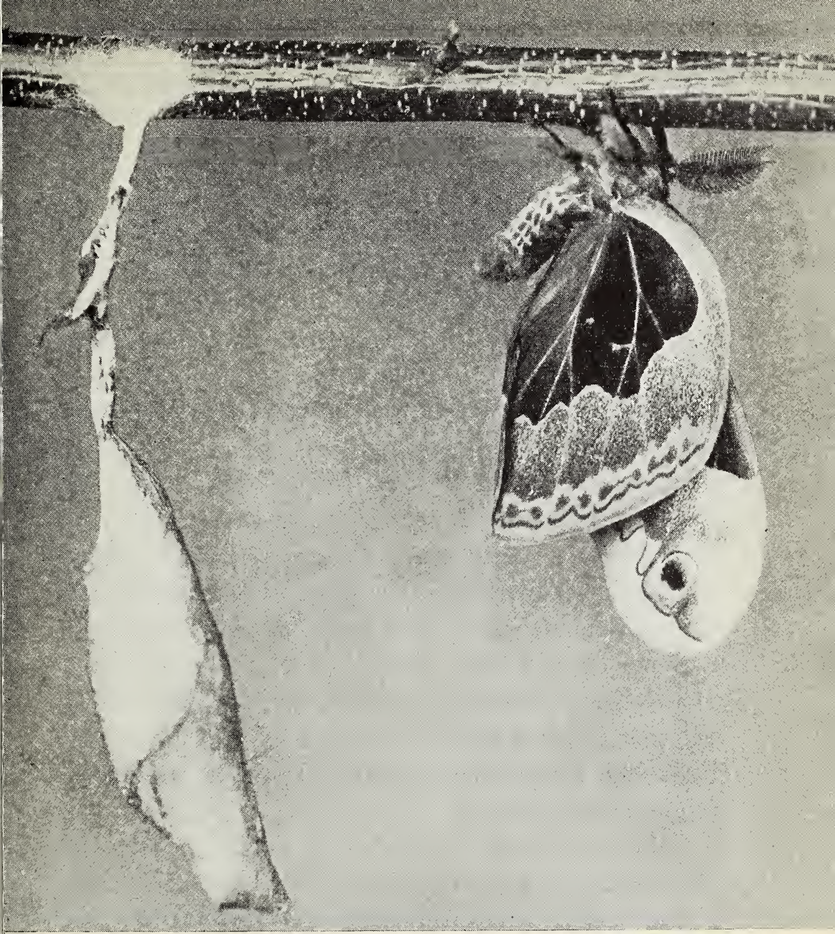
of legs near the head. These are called the forelegs. They are like the legs which the adult butterfly or moth has. Most caterpillars have five other pairs of legs. These legs disappear when the insect becomes a butterfly or moth.

A caterpillar is usually very hungry. Its jaws are powerful and are good for cutting and chewing. It eats and eats until it cannot eat another mouthful. The skin becomes too small. So the caterpillar rests and gets ready to molt, or change its skin. The skin splits down the middle of the back. The caterpillar crawls out. It has grown bigger. Soon it begins to eat again. The caterpillar may shed its skin in this way four or five times. Now it is as big as it will ever be. So during the late summer or fall it turns into a pupa, or chrysalis.

As a pupa, the caterpillar does not eat. It does not crawl about. It does not do anything but rest and wait while its body changes and its wings grow.

Different caterpillars get ready for their pupal stage in different ways. Some of them make tiny silk mats on a leaf, on a twig, or in some sheltered spot. They fasten themselves to these silk mats. There they hang quietly while their bodies change and their wings grow. Some caterpillars burrow into the ground and make little caves. Here they stay during their pupal stage. Some caterpillars spin yards and yards of silk, which they make into coverings, or cocoons. In such a cocoon the pupa is protected while its body changes.

The different kinds of caterpillars do not all remain in the pupal stage the same length of time. Some



Lynwood Chace

This Polyphemus moth has just come out of the cocoon where it stayed during the winter

change to butterflies in about two weeks. These may die before the autumn comes. Some need a longer time. Most moth caterpillars remain in the pupal stage dur-

ing the winter. This is the resting stage in the life of the butterfly or moth.

After a while the butterfly is ready to come out. The chrysalis opens. The opening grows wider and wider until the whole body of the insect is out. As soon as the feet appear they find a place on the old chrysalis skin. Here the butterfly hangs and rests in the warm sun. It seems quite helpless. Its wings are soft and moist. They are folded close to the body. But soon the moist wings are dry and strong. Away flies the butterfly into the air and sunshine.

The young moths must break their way through the cocoon. In the warm spring sunshine they too hang and dry their wings until they are ready to fly away.

So a butterfly or a moth changes in appearance four times. It is an egg. It is a caterpillar, or larva. It is a pupa, or chrysalis. Finally, it is a butterfly or a moth. These changes take place through the seasons. Scientists have a special word for the way butterflies and moths change in growing up. They call this changing metamorphosis.

Other insects go through changes as they grow up. These changes are not exactly like those of the moth and butterfly. We shall talk about some of these other insects later.

Perhaps you would like to watch some moths and butterflies grow up. When you take walks through the woods in the autumn, look for cocoons and chrysalises. You will find them hanging from twigs and branches of trees. Break off the twigs very carefully and bring

the cocoons to school. If you keep the cocoons in a very cool place, they will not come out until spring. A good place for your cocoons will be just outside your schoolroom window. If you keep the cocoons or chrysalises in your room, be sure to sprinkle them with water about once a week. These moths or butterflies kept in the room may come out very early in the spring. Do you know why?

Lynwood Chace

This is a full-grown Luna moth

You might try to find out the names of your moths and butterflies. Some of the largest and most beautiful moths are the Cecropia, the Luna, and the Polyphemus. Some of the butterflies might be monarch butterflies.

ANIMALS CHANGE IN COLOR

Some animals change in other ways as the seasons change. Just as many plants change in color, so do many animals. These animals have a summer color and a winter color.

When winter comes in the Far North, the arctic fox and the ermine become as white as the snow that

covers the land. Their white fur makes it difficult for their enemies to see them. In the summer the fur of the arctic fox is blue-gray. The ermine is reddish-brown on the back and yellow underneath during this season. The tip of its tail is black during the whole year, however. The skin of the ermine must be taken in the winter if the man who traps them wants the beautiful white fur which is made into ermine coats.

Some birds also change in color during the year. The white-tailed ptarmigan is a bird with white winter feathers. During the summer it is brown and gray. Can you tell how this would help in protecting this bird? So, as the seasons change from spring to summer to fall to winter, the ptarmigan's feathers change in color.

THINGS TO THINK ABOUT

1. Do you think animals know when winter is coming and are able to make their colors change?

or

Do you think the color of animals just changes without their thinking about it?

2. Do you think plants know when and how to store food so that there will be food for early spring growth?

or

Do you think food is just stored in some part of a plant and then used in the spring?

THINGS TO DO

1. Notice the color of the robin's feathers early in the spring. During the late summer the feathers will begin to change in color. Watch for this change. What color do you think the feathers will be in the fall?

2. Visit a zoo several times during the year. Watch to see if the animals change in color. Do they have a heavier coat of fur or feathers in the winter?

III

Migration

THE MIGRATION OF BIRDS

OTHER ANIMALS THAT MIGRATE


LATE JUNE AND JULY
AUGUST
JUNE
EARLY SEPTEMBER
MAY
EARLY MARCH
EARLY MARCH
EARLY SEPTEMBER
SEPTEMBER TO FEBRUARY
Summer Plumage
Winter Plumage
ROBERT H.

LONG before Columbus discovered America people had noticed that many birds disappeared in the autumn. At that time people knew little about the world. They had no idea where the birds went. So they invented many strange stories to explain their absence.

Today we know more about where the birds go, but we find there is much about their migration, or travels, that we do not know. An aviator carries maps and compasses which help him in finding his way. Do birds carry maps and compasses when they make the long journey to their winter home and then back to their summer home? Even the young birds that have never made the trip before do not get lost.

The yearly migration of the golden plover is shown in the picture on page 71.

Many birds migrate over mountains and deserts and across the seas; some migrate from the arctic to the antarctic and back again every year. Why do they do it? Why do they not make their homes in the tropics and in that way escape all the dangers of so much traveling?

These questions have puzzled people for a long time. Many scientists spend their lives studying them. Here you will find some of the things they know and some of the things they are still trying to find answers for.

The Migration of Birds

GREAT BIRD TRAVELERS

One of the greatest travelers among birds is the arctic tern. Some of the arctic terns travel from the antarctic to the far, far, north each year. They make their nests and raise their young on the arctic coast of North America. The mother terns often make their nests in the snow. In these snowy nests the little birds are hatched. It is said that an arctic tern's nest has been found as near as four hundred and fifty miles to the north pole.

When the young have been raised, the arctic terns begin to fly back to the antarctic regions. At the end of their journey, the parent birds have traveled over twenty-two thousand miles. They have flown almost as many miles as the distance around the earth. Do you not think these birds should be called great travelers?

Golden plovers are great travelers, too. They spend the winter in the southern part of Brazil and travel to the northern coast of North America in the summer. These birds do not come and go over the same route. When traveling north, they fly along the western side of South America to the United States. Here they follow the Mississippi Valley into Canada and the northern coast of North America. In going to their winter home, they fly across Canada to Nova Scotia. Then they go south to Brazil. Sometimes they may fly over two thousand miles without stopping.

Allan D. Cruickshank, from National Association of Audubon Societies

Large arctic terns and small hummingbirds migrate long distances each year. Could you guess how far a hummingbird may migrate?

Have you ever seen little hummingbirds in a flower garden? They fly about the blossoms to get the nectar, or sweet juice; then they dart away quickly. These tiny birds have traveled all the way from Central or South America. Is it not strange to think of such little birds taking such long journeys?

We have learned a great deal about the long distances that birds travel by putting bands on the legs of birds. These bands are usually made of aluminum. They are light and do not harm the bird. They are marked and dated. One must get permission to put a band on a

bird's leg. Permission to band birds in the United States is given by the United States Biological Survey in Washington. In Canada it is given by the Department of Mines and Resources in Ottawa.

WHY DO BIRDS MIGRATE?

Do you like to do puzzles? Sometimes questions are asked that are real puzzles because they are so hard to answer.

Why do birds migrate? is one of the most puzzling questions that has ever been asked. No one seems able to answer it. Since early times scientists have been carefully studying the travels of birds in order to answer the question. But these scientists are not yet sure what it is that causes the birds to travel over such distances every spring and fall.

Some scientists think that birds migrate in order to get food. When winter comes, there is very little food for birds in the cold northern countries. So most of them fly south, where it is warmer and where they find more food. Then the southern places where there is plenty of food become crowded with birds from the north. When spring comes, there is more food in the northern countries. Then the birds fly back.

But this does not really answer the question why birds migrate. We know that there are many birds that leave their northern homes in the late summer. They fly south while the weather is still very warm and while there is still plenty of food in the north.

Black Star

These migrating swallows are resting before continuing their long journey

Other scientists think that the very first birds of the kind that migrate today were born in the north. Their first homes were in the north. Then there came a great change in the climate of certain parts of the earth. It became so cold that the summer sun was not warm enough to melt the snow and ice formed during the winter. Snow fell and hardened into ice. This went on for many, many years. At last a huge ice sheet covered the northern part of North America. The winds blew over the ice sheet and then across the country near it. The birds tried to get away from the cold of this great ice mass. So they traveled to the south, where the climate was warmer. Thousands of years passed, and the climate of the northern countries again changed, and slowly became warmer. Then the ice sheet melted, and the birds moved north. As the seasons continued to change from spring and summer to autumn and winter, the birds soon began to move to the south in the winter and to the north in the summer. No one really knows whether this is true. It is just one explanation of why birds migrate.

Here is another explanation which is given to show why birds migrate. At one time all birds lived in the warm south. The southern countries became very much crowded. It was difficult for all the birds to get all the food that they needed. This was especially true during the time when the young had to be fed. Young, growing birds need a lot of food. Many of the birds were forced to find new homes in order to raise their families. They traveled into the northern countries. When the

young birds were able to leave the nests and fly, the father and mother birds returned to their winter homes.

This explanation seems to be a good one. Birds do build their nests and raise their young in places where they cannot spend the winter. They must migrate to other places.

However, scientists are not willing to say that any of these explanations tell us why birds migrate. They are still giving a great deal of time and thought to the question.

THE TIME OF YEAR WHEN BIRDS MIGRATE

Some boys and girls always want to be the ones to see the first robin and the first bluebird in the spring. They watch for them day after day. They know that as soon as the snow has gone in the northern countries, many of the stronger birds will arrive from the south. Some of them come while the snow is still on the ground. These first birds to arrive do not spend the winter very far south. When the first warm days come, they begin to travel north.

When spring really comes and the weather grows warmer, most of the early travelers among the birds appear. They begin to make their nests. We call them our summer residents, because they remain with us most of the summer.

The birds that come later in the spring may stop along the way to feed, but they soon fly on farther north.

During April a few new birds arrive daily. By the

last of May the great spring migration of birds is usually over. Most of the birds have reached the places where they build their nests. They do very little traveling during the nesting time.

The spring migration is a very orderly one; but the autumn migration of the birds is not quite so orderly. Many birds, such as the Baltimore orioles, some of the warblers, and the bobolinks, leave their nesting places early in the autumn. They fly back to their winter home long before cold weather comes and while there is still plenty of food.

But many birds wait in the north until the nights become really frosty. Then they hurry on their way south. Other birds wait until the cold winter storms drive them away.

In the late fall juncos, redpolls, tree sparrows, pine grosbeaks, and snowy owls are among the birds that come from far, far north. They stay with us all winter. We call them winter residents.

Some birds remain in the places that have a mild, temperate climate most of the year. They are called permanent residents. Chickadees, nuthatches, and some of the woodpeckers are birds that may be seen all winter. They search for food on the bare branches and trunks of the trees. The noisy blue jay may also often be heard during cold weather. Even among the birds that stay through the winter, there is a certain amount of traveling back and forth.

In high, mountainous countries birds migrate by traveling a few miles up and down the slopes of the

Acme

Have you ever seen geese migrating?
They fly in formation with a leader

mountains. When the tops of the mountains are covered with ice and snow in the autumn, many birds suddenly appear in the valleys. They have only a short distance to go; so they do not need to hurry. There is plenty of food for them. When the snow and ice disappear from the tops of the mountains in the summer, the birds travel up the slopes of the mountains. There they build their nests and raise their young.

THE TIME OF DAY WHEN BIRDS MIGRATE

Some birds travel during the day. Some travel during the night. Others travel at almost any time of day. The time of day when birds migrate depends on the kind of bird.

Many of the small birds travel at night. Warblers, wrens, orioles, sparrows, and vireos travel when it is dark. These, and other small birds, have many enemies. By migrating at night they are able to escape some of their enemies. Many of the small birds live in the woods. They are hidden from view by the leaves of the trees. This makes them shy and easily frightened. It seems better and safer for them to fly at night.

When these birds travel all night, they become very hungry. They need food; so they spend the day in feeding and resting. Sometimes these little birds travel great, great distances over land and water. If they flew during the day, they would arrive at their stopping places after sunset, and they might not be able to get the food they needed. People often hear the cries of these small birds as they fly on, calling to each other in the darkness.

The larger and stronger birds travel during the day. Robins, bluebirds, blackbirds, and kingbirds are among the birds that travel in the daylight. Many of these birds stop to feed while they are on their way.

When these birds are traveling north and south, they often have to cross great bodies of water and some places on land where there is very little food. When this hap-

pens, they change their time of migrating and fly at night. In this way they reach places where they can feed by daylight.

There are birds that feed as they fly. Swallows and chimney swifts do this. They need not stop for food.

Ducks, geese, cranes, loons, and hawks are very large birds, and they usually travel during the day. They rest at night. But if there is a sudden change to cold weather when they are migrating, they may travel either by day or by night. Long lines of them may often be seen hurrying to a warmer place.

After the birds have begun their journey to the north or to the south, they hardly ever turn back. But they may stop on the way if the weather is stormy and unpleasant.

While the birds are traveling back and forth, they meet many dangers. There may be sudden storms from which the birds are not able to get away. They are tossed about by the wind and perhaps blinded by the rain or snow. Hundreds of them may die during a storm. The larger migrating birds often attack and kill the smaller, weaker ones. Other animals often catch and kill the birds when they stop to rest and feed.

THE SPEED OF BIRDS

Perhaps you have wondered how fast birds travel when they are migrating. Birds that leave their winter homes when the first warm days come travel slowly. Stormy weather often prevents the early birds from

making much speed. The birds that wait until April and May to start north move very rapidly. Then the weather is warmer, and most of the bad storms are over. It is thought that the smaller birds usually travel about twenty-three miles a day.

The blackpoll warbler starts north from South America at the rate of thirty to thirty-five miles a day. As it travels through the United States to northwestern Alaska its speed is much faster. Some days it flies two hundred miles in one day. It travels this long distance in order to raise its young in the Far North.

In some places robins travel only eight miles a day. In other places they may travel seventeen miles a day. In still other places they are known to fly over seventy miles in one day.

It has been found that some birds can travel over two hundred miles an hour. An airplane or automobile must be built for speed and have a good motor if it is to travel so fast. Birds too are built for speed in that they have light bodies, strong wings, and plenty of energy and are able to steer themselves. Aviators have found that certain birds are able to fly around their airplanes which are flying seventy miles an hour.

Birds may or may not be helped in their journeys by the wind. Did you ever try to walk when a strong wind was blowing in your face? Were you able to walk very rapidly? When a bird flies against a head wind (that is, when a strong wind is blowing in its face), it has a hard time. It must use a great deal of its strength and energy. Because of the head wind, the bird's speed

is cut down. It cannot travel fast. The bird also has trouble when it travels with the wind. Then its feathers are being blown about. This makes it harder for the bird to fly. It is difficult for it to keep its balance. Light winds from other directions help to push the birds on their way.

Do you know how high some of the birds fly? Large, strong birds have wide wings. It is easier for them to fly high than it is for the smaller birds. Hawks, eagles, and cranes belong to the group of strong birds. They may fly very, very high.

Aviators have found out a great deal about the height to which birds fly. They tell us that only now and then have they seen a bird higher than a mile and a half above the earth. They have found most of the birds that migrate flying less than half a mile above the earth. Sometimes they have seen a bird flying above very high mountains. This does not often happen.

The message which this homing pigeon carries is in the metal box fastened to its leg. How do homing pigeons find their way?

Keystone

HOW DO BIRDS FIND THEIR WAY?

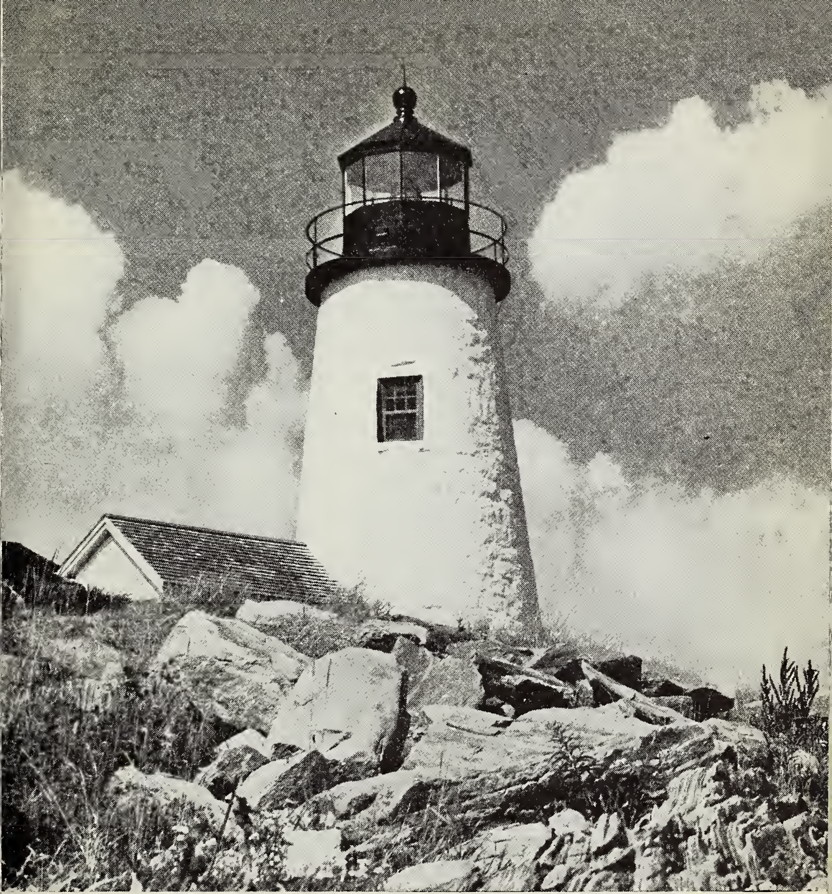
Most birds seem to have very good eyes. They are able to see a long distance away. The birds that fly in the daylight may be guided a great deal by the things they see. The night-flying birds may also depend on their sight to guide them on their way. On a clear moonlight night these birds fly very high. When the night is cloudy or foggy, they fly only a short distance above the earth.

The dog and the cat find their way about by what is called their sense of direction. We think that birds may have a sense of direction, too. However, we are not sure of this. No one knows what a sense of direction really is. But we think it is different from thinking or remembering. We believe that most animals cannot think.

We know that homing pigeons have traveled great distances and returned again to their lofts. They have done this with very little loss of time. Their sense of direction may have helped them to find their way.

From the many experiments that have been tried with pigeons, it would seem that they do recognize places and that their sense of direction guides them. It may be that all birds are helped in traveling back and forth by their sense of direction.

On dark, stormy, or foggy nights many birds get lost. Many of them fly to the rays of light that are thrown out by lighthouses. They often fly about for hours in the mist around the light. Then they become tired out and fall.



Roberts

The platform on this lighthouse may be a resting place for birds on stormy nights

In many places people who are interested in protecting birds are having platforms built under the lights in the lighthouses. On these platforms the birds may rest until they are ready to fly on their way.

HOW THE EARLY PEOPLE EXPLAINED THE MIGRATION OF BIRDS

Early people had many strange ideas about birds. They too tried to explain why birds migrated. Many, many years ago they noticed that the birds disappeared from certain places in the autumn and winter. When spring and summer came, the birds returned.

The fact seemed very strange to those people of long ago. They wanted to know where the birds went. They wanted to know why they went.

Some of the people thought that the birds went straight to the moon when they left in the autumn. It took them about sixty days to reach the moon. They did not need to eat on the way. They would not starve because they had plenty of fat stored up in their bodies. There was nothing between them and the moon; so they closed their eyes and flew on, fast asleep.

There were other people who said that the birds went into caves and hollow trees and slept during the long, cold winter. They thought that some birds buried themselves in the mud at the bottom of streams and in very wet places. They were sure that swallows and chimney swifts passed the winter in this way. They told a story about some men who were fishing. When the fishermen drew in their nets, they found as many sleeping swallows as fish. They also said that swallows were dug from a depth of two feet in the mud. Half an hour after they were dug up, the swallows awakened and became lively and active.

There were still other people who believed that the birds changed from one form to another as winter came. Robins were supposed to take the form and colors of redstarts. Certain birds that lived in wet places were thought to change into frogs.

All these stories were told by the early people because they were so anxious to explain why the birds disappeared in the autumn and winter.

Birds have been migrating for thousands of years. Scientists of today cannot tell us why they do it. What a difficult question the early people tried to answer!

THINGS TO THINK ABOUT

1. In what ways is an airplane like a bird?

2. Why cannot birds fly to the moon?

3. We may think some of the early explanations of the migration of birds are very funny. But have you ever thought that those early people were making the best explanations they could of why birds migrate? Perhaps many, many years from now people will be much amused at the explanations we make about the migration of birds.

THINGS TO DO

1. Try to find out what birds stay near your home (*a*) only in the winter; (*b*) only in the summer; (*c*) only during migration; (*d*) all year long.

2. On a map of the world (*a*) trace the journey taken by the arctic tern in going from its winter to its summer home; (*b*) trace the two routes taken by the golden plover.

Have you ever made a journey as long as that of either of these birds? Just think! Each of these birds makes its long journey every year.

Herds of reindeer, like these in Canada, migrate during the fall and spring

Other Animals That Migrate

We know that many animals travel about from place to place. They may travel in search of food. They may travel to raise their young. They may travel to find a different climate. Whatever the cause is, many animals do travel from one place to another.

In early times man had to hunt and fish in order to live. There were no markets. There were no stores where he could buy what he needed. He soon learned to know the habits and the movements of the animals that would furnish his food and clothing. He found that certain animals were in certain places during part of the year. The great herds of buffaloes, or bison, traveling across the plains filled him with joy. They meant food and clothing for him. These buffaloes were migrating. They were hunting for new pasture.

The Indians have many old legends which tell of the coming of the caribou, or reindeer, to their hunting grounds. These animals migrate by thousands each year. They must migrate to find new pastures.

Reindeer feed on moss. During the winter they travel from the shore far into the country to find it. In the summer, when flies and mosquitoes make their appearance in the country away from the shore, the reindeer migrate back to the coast.[1]

Polar bears spend much of their time during the

[1]The picture on the opposite page is used with the permission of the Lands, Northwest Territories and Yukon Branch, Department of the Interior, Canada.

summer on the loose ice far from shore, hunting their food. In the winter this ice moves southward. The polar bears travel south with the ice. They are then often found on land. The mother bear usually selects a den on the ice. Here in the silence of the long, cold, northern night, one or two little naked cubs are born. The mother takes good care of her young. When the ice breaks up and the cubs are able to follow, the family migrates a greater distance to the north.

Beavers are often found wandering about searching for new forests and fresh food. They usually travel about in the spring. During the winter they stay close to their homes. They eat the food which they store there in the summer.

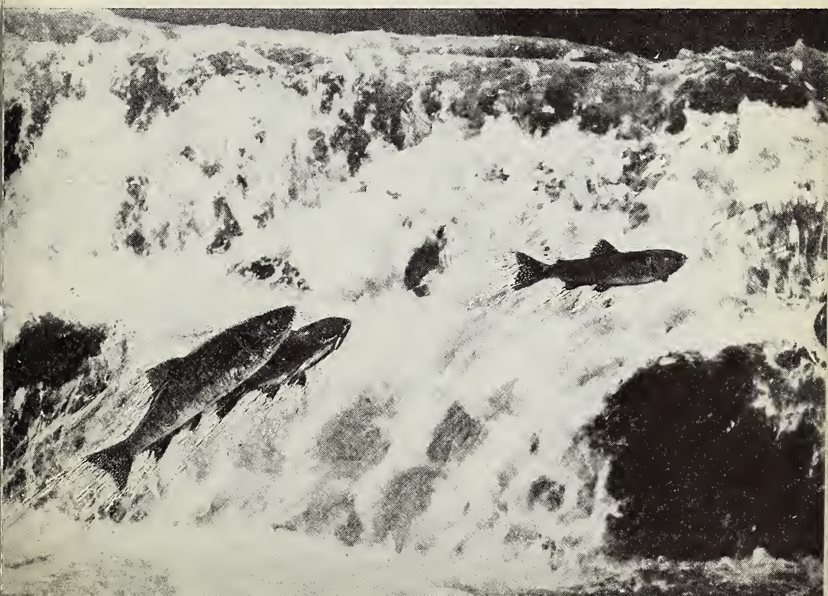
On the slopes of the mountains sheep and mountain goats are found. They travel up and down the slopes, hunting for food, shelter, and warmth. Usually in the summer they find food high on the mountainside. In the winter they must come down nearer the valley for food and shelter.

Salmon travel great distances. They go from the salt water of the ocean to the headwaters, or the source, of certain streams. They take this long journey to lay their eggs. This journey takes place in the spring. They lay their eggs in the gravel and sand at the bottom of the stream. The baby fish develop, or grow, slowly. About eight weeks after they are born, the little salmon move through the water searching for food. When the little fish measure six or seven inches in length, they are ready to go out to the ocean. Here they grow very

rapidly. A few years are spent in the ocean in feeding and growing. Then the salmon are ready to lay eggs. They leave the ocean and go to the headwaters of streams.

The journey from the ocean to the source of the stream is a difficult one for the salmon. The fish must travel against the strong current in the rivers. They must leap over many falls. They probably travel without food, living on the fat that is stored in their bodies. Few of the salmon ever lay eggs more than once. Their life then seems to be ended, and they die. So salmon do not migrate every year; they migrate only twice during their entire lifetime.

The journey of salmon upstream is a very dangerous one.
Do you know why they make this journey?



© Screen Traveler, from Gendreau

These people are called nomads, or wanderers, because they migrate from one place to another in search of good homes

Shad leave their home in the sea and migrate long, long distances up rivers. They also go to the headwaters of the streams to lay their eggs.

Have you ever seen an eel? It is really a salt-water fish; but it spends most of its life in fresh or slightly salty water. Eels migrate; but they do not do it in the same way that shad and salmon do. On autumn nights the parent eels may be found traveling from the quiet waters of the rivers and ponds to the sea. They swim out into the deep water, lay their eggs and probably die. Big eels never return to their homes in the rivers and ponds. Very little is known about the eel's eggs. When young eels are a certain size, they migrate toward the shore. They pass up the fresh-water streams to feed there and grow.

Alaskan fur seals and whales are other migrating animals that spend much of their time in the sea. The seals travel far south through the warmer water of the ocean each year. When spring comes, many return to the islands in Bering Sea to raise their young.

Whales are large sea animals. They travel about, probably trying to find a more steady temperature. The need of food may be one reason for their movements. The killer whale will follow, kill, and feed upon seals. It travels about to find them. So the whales, in following the seals, migrate south in the winter and north in the summer.

Very little is known about the migration of insects. Monarch butterflies, cabbage butterflies, and locusts are insects that are supposed to migrate.

It is thought that the monarch butterflies seen in the north in the spring have come from the south. Most of them return to the south during the winter. These animals, then, usually migrate with the season.

Now and then migrating locusts appear in great numbers in certain countries. They do much damage to plant life in these countries. Sometimes whole fields of grain are destroyed by locusts. They seem to migrate any time when they have eaten all the food in one place. They do not migrate according to the season.

Man migrates, too. From Asia he migrated westward into Europe. He crossed the Atlantic Ocean and spread into the land of the American Indian. Today people who live on the borders of desert countries must travel about to find food for their flocks.

There are many animals that migrate which are not mentioned in this story. Only the animals that most of us know about or have seen are given.

You may be able to name other animals that travel from place to place at about the same time of the year so that they can find enough food.

THINGS TO THINK ABOUT

1. Why do we no longer find great herds of buffaloes wandering over our plains?

2. What is the best time of the year to catch shad and salmon for food? Why? Do you think any company should be allowed to catch as many salmon as they wish?

3. Why do not most people migrate as some other living things do?

THINGS TO DO

1. Try to find out how some of our large dams are built so that salmon can still swim up the rivers.

2. Watch for migrating insects. Do you think they migrate only in the spring and fall or whenever their food supply is used up?

IV

Hibernation

WHAT IS HIBERNATION?

SOME ANIMALS THAT HIBERNATE

SOME animals must hunt for food every day during the winter. Perhaps they find seeds, nuts, or other things to eat. Perhaps they are able to get bits of grass here and there. These animals need a great deal of food, because they are exercising in the cold. Some animals store food before winter comes. The picture of the chipmunks shows how they store food for winter use.

Some animals neither migrate nor look for food in winter. They go off into some protected place away from the cold air and sleep. How can they spend the whole winter without eating or drinking?

A man who spent much of his time studying animals once said that the woodchuck goes farther than the bobolink in the winter. The bobolink goes south, but the woodchuck goes to the very doors of death. What do you think he meant? The next story may help you to answer this question.

What Is Hibernation?

Did you ever see toads and frogs hopping about outdoors in the winter? Long before really cold weather comes, they have disappeared. They have found places deep down in the ground or in the mud at the bottom of a pond. Here they have buried themselves and so escape the cold of winter. We say that they are hibernating.

You will not see turtles and snakes crawling around hunting for food in winter. The turtles are buried in the sand and mud of the streams. Many of the snakes have found safe places under the stones and rocks on stony hillsides. They have crawled into these places to rest and sleep until winter has passed. These animals are also hibernating.

Passing the winter, as some animals do, in resting and sleeping all or most of the time is called hibernation. We usually think of hibernation along with cold weather.

Scientists are not willing to say that the animals that hibernate do so because of the cold. Many scientists think it is because the hibernating animals cannot get the food they want in cold weather.

Both warm-blooded and cold-blooded animals hibernate. A cold-blooded animal is an animal whose body temperature is about the same as the temperature of the air, water, or land about it. Fish, turtles, snakes, and frogs are cold-blooded animals. The body temperature of a snake which is in the warm sun is higher

than that of a snake under a rock or in a hole in the ground. The body temperature of a turtle in the water is less than that of a turtle in the sun.

Warm-blooded animals are those animals whose body temperature stays about the same no matter what the temperature of the air or water around them may be. We are warm-blooded animals. Our temperature is about 98.6 degrees whether we are swimming in cold water or sitting in the hot sun. Of course our temperature may go up or down when we are ill. A few of the other warm-blooded animals are dogs, whales, and birds.

As we have said, both warm-blooded and cold-blooded animals hibernate. But the number of warm-blooded animals that do so is very small. Most warm-blooded animals either run about all winter searching for food or migrate to a place where there is plenty of food.

Many animals that hibernate during the winter prepare for their long sleep in a special way. Some of these animals are busy all summer getting ready for the winter. They gather and store great piles of food. This food is stored in the burrows, or homes, which they make for themselves in the ground. The food and the animals will not freeze. The burrows are made deep so that frost will not reach them. When the cold weather comes, the animals go into their burrows, curl up, and hibernate. At certain times during the winter some of them may wake up and eat. But they go to sleep again. Chipmunks do this.

Other animals eat a great deal of food during the summer. That is their way of getting ready to hibernate. As cold weather comes, they eat more and more food. Instead of storing food in their burrows, they store it as fat in their bodies. These animals usually hibernate all winter without waking up. They live on the fat stored in their bodies. Woodchucks hibernate in this way all winter.

Many changes take place in the bodies of animals when their hibernating time comes. Their mouths, noses, and eyes close tightly. Their hearts beat very slowly and feebly. Their breathing becomes very, very faint. Many of the animals grow thinner and thinner and lose weight. They are alive. But they are very, very still.

Do all animals that hibernate stay in their burrows or holes the same length of time? No, the length of time that hibernating animals sleep differs with different animals. Some animals may sleep four months. Some may sleep less than a month. A scientist once kept some hibernating land snails for three years. They were wrapped in paper. At the end of three years the paper was taken off. The snails were still alive.

Some animals hibernate during only a part of the winter; so they are called partial hibernators. Chipmunks, bears, raccoons, bats, and skunks are partial hibernators. A skunk may hibernate only a few weeks during the early part of the winter. If mild, warm days come while it is sleeping, it may wake up and come out of its den.

Some animals hibernate only when the weather is very stormy and cold. When it grows warmer, they awake and become active. This is true of porcupines, opossums, muskrats, meadow mice, and squirrels.

Other animals rest during the entire winter. They are the regular hibernators. Woodchucks, ground squirrels, turtles, snakes, lizards, snails, toads, and frogs belong to this group. Mourning-cloak butterflies, queen bumblebees, and potato beetles are also regular hibernators.

You have been reading about animals that hibernate during the winter. There are animals that do not hibernate in this way. They do not store food for cold weather. Deer, rabbits, foxes, and many other animals must hunt about for food all winter long.

The next stories will tell you more about some of the hibernating animals.

THINGS TO THINK ABOUT

Which body do you think would need more food for its size, (*a*) that of a boy or girl with a temperature of 98.6° F.

or

(*b*) that of a bird with a temperature of 101.5° F.?

Remember that the heat energy for the body comes from the food eaten.

THINGS TO DO

Watch for animals that are storing food for the winter. Do they look smooth and fat? How do you think they will look in the spring?

Some Animals That Hibernate

WOODCHUCKS

Woodchucks have other names. Many people call them ground hogs.

Woodchucks usually live in an open field that is not far away from a wood or hill. The home is in a long burrow under the ground. This burrow is made very carefully, so that the nest of grasses and leaves will keep dry. There is a front door and a back door to the burrow. So a woodchuck may go into his burrow one way and come out another. Near the front door is a little pile of loose earth. But the back door is usually hidden under sticks, twigs, and stones. The doors of the nest are often closed in order to keep other animals out.

Woodchucks eat food all summer. In the fall they eat more and more. Finally, they have eaten enough food to last them through the long winter.

When a woodchuck has finished eating, he goes into his warm, cozy nest, curls up, and hibernates. His temperature gets lower and lower. He breathes very slowly. His heart beats very slowly. It beats just enough to keep the blood flowing through his body.

If a woodchuck is dug out of his burrow in the middle of the winter, he does not seem to be alive. His body is cold and stiff. But he is not frozen. If he is kept in the warm sunshine long enough, he will wake up.

Woodchucks are born in April or May. There may

This woodchuck is taking a sun bath after spending the winter in hibernation. Do you know what happens to a woodchuck when it hibernates?

be three or as many as nine little ones. It is great fun to watch them follow their mothers through fields and meadows. The mother takes care of her young for a few weeks; then they take care of themselves. These young woodchucks eat and eat all during the summer. When cold weather comes, they hibernate just as their parents do.

There is a story about the ground hog which says that he always comes out of hibernation on February 2, and that if he sees his shadow on this day he hurries

back to his nest, because he knows there will be six weeks more of wintry weather.

We know this story is not true. In the first place, woodchucks do not all hibernate the same length of time and so do not all come out on the same day. Then, the woodchuck probably would not come out at all if the weather were cold. He would still hibernate. However, if the weather is warm for a week or more before February 2, the ground hog may come out of his burrow. It is near enough to spring so that warm weather would wake him up. But he would not rush back to his burrow just because the sun was shining. He would probably stay out and sun himself. If the weather should be cold again, which it usually is in March, he would most likely go into hibernation again.

So the story has little truth. Ground hogs are not able to tell what the weather will be. During the warm summer days they eat a great deal, because there is plenty of food. During the long, cold winter days they hibernate.

BATS

Bats are the only mammals that really fly. Flying squirrels glide downward through the air; but they do not really fly.

In the evening bats fly in and out among the branches of the trees, catching insects, while most of the birds are sleeping. Before the light of morning comes, they are again hunting for food. Bats do not have to stop

American Museum of Natural History

These are little brown bats hibernating in a cave

to feed. They eat as they fly. Mosquitoes, moths, and other insects are their food.

The body of a bat has a covering of soft hair, or fur. However, the wings have no such covering. There are

many little blood vessels and nerves in them. Even if bats could get insect food in the winter, the wings could not stand the cold. Bats would not be able to fly in cold weather; so they hibernate.

When bats hibernate they do not make a nest or burrow as woodchucks do. They find an old house, a barn, a cave, or a hollow tree. Then they hang themselves up, head down, and hibernate.

Bats are very helpful animals. They eat mosquitoes, flies, and other insects that bother us during the summer. Some people are afraid of bats because they have heard such foolish stories about them. These stories are not true. There is no reason why one should be afraid of a bat.

Bats, then, do not migrate as some birds and other animals do. They hibernate during the winter. Of course fat is stored up in their bodies during the warm days. If they did not have this fat, they could not live during their hibernation period.

CHIPMUNKS

A chipmunk is a friendly, playful little animal. He looks like a very small squirrel, except for the black and white stripes along his back and sides. These stripes protect him. They look so much like the grasses and bushes that they make him difficult to find when he is at rest. You can see a chipmunk only when he moves. He spends more time on the ground than in the trees. His claws are not sharp enough for much tree-climbing.

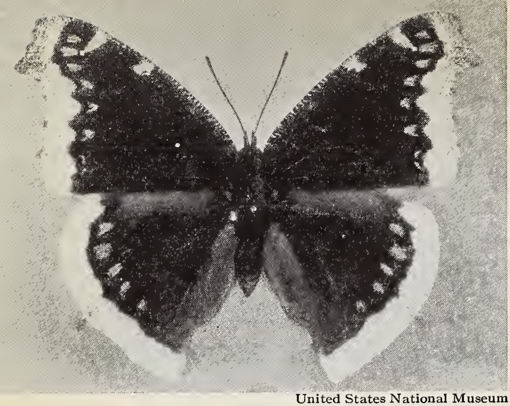
He is often found in cemeteries, where he hides and burrows under the tombstones. On a stormy day he goes under a log, a tree stump, or a stone and rests.

Chipmunks gather plenty of food for the winter hibernation. Sometimes they hide a great many nuts, seeds, and grains under logs, in holes in the ground, and in trees until they have time to remove them to their burrows. It is said that chipmunks and squirrels can tell the difference between good and bad nuts without opening them. They will take the good nuts and leave the bad ones. How do you think they know good nuts from bad ones? Besides nuts, they often eat apples, wild berries, some kinds of vegetables, and mushrooms.

Few animals build a better home than chipmunks. They usually make a burrow on a dry hillside. The entrance to it is only large enough for the body. A long tunnel runs back from the entrance to the warmly lined nest. There is also a back door by which chipmunks leave their tunnels.

It is fun to watch a chipmunk when he is making his burrow. He looks very much like a child who has the mumps. He has little pouches, or pockets, on the inside of his cheeks. In these pouches he carries every bit of loose earth away from the entrance of the tunnel he is digging. There is no pile of earth to show where the nest is.

Chipmunks spend most of the winter hibernating in the nests that they make. On mild days they may wake up and come out of the burrow. Some of the stored-up food is usually eaten at this time. Then they go back


United States National Museum
Mourning-cloak butterflies hibernate. Many butterflies do not

to the nest. Now and then a chipmunk awakes, eats some food, and goes back into hibernation without going outside the burrow.

So chipmunks also change their way of living with the seasons. They are active during the spring, summer, and autumn. They may even come out of their burrows on sunny winter days. But these animals, like woodchucks, hibernate during the cold winter days.

MOURNING-CLOAK BUTTERFLIES

On a warm sunny day in late February or early March, large dark-brown butterflies may be seen flying about. They are mourning cloaks. Their dark-brown wings have a narrow border of bright yellow. Near the yellow border there are many lovely bright-blue spots that add to the beauty of the butterfly.

If you watch a mourning cloak as it flies about, you may see it alight on the trunk of a tree and fold its wings above its body. Then it begins to drink with its long black tongue the sweet sap that is slowly coming out of a small hole in the tree. Other mourning cloaks may soon join it. They too are hunting for food.

Mourning cloaks hibernate during the winter. As very cold weather comes, this butterfly finds a safe place where it will be protected from storms. This place may be in a barn, in a hollow tree, under a woodpile, or in any other sheltered spot. There it folds its wings above its body and hibernates.

QUEEN BUMBLEBEES

A queen bumblebee also passes the cold wintry days hibernating. She usually finds a dry, sandy place and digs a nest. Here she rests while cold weather lasts.

In the spring she wakes up, crawls out of her winter home, and hunts for a larger nest where she can lay her eggs and raise her family. She usually selects an old burrow that was once the home of a field mouse. Then she gathers enough pollen and nectar from the flowers to make a loaf of beebread. On this beebread

It would not be easy to find the nest of a hibernating queen bumblebee. Do you see why this is true?

she lays her eggs. The eggs soon hatch out, and the new bumblebee family has begun.

What do you suppose would happen to bumblebees if the queens did not hibernate during the winter?

TURTLES

Turtles belong to the reptile class of animals. They are cold-blooded. People have found turtles that were over thirty or forty years old. They knew this was true because of dates which other persons had carved on the shells of the turtles many years before. Many turtles live to be very, very old. It is said that the turtles around the Galápagos Islands, which are off the west coast of South America, are the oldest living animals today. Some of them are nearly two hundred years old.

A spotted turtle like this one makes a good pet.

What do you suppose he will do in the winter if he is kept out of doors

American Museum of Natural History

Many turtles are not able to stand cold winters. Therefore they hibernate until warm weather arrives. They do not make burrows like woodchucks and chipmunks, nor do they hang themselves up like bats. But they bury themselves in a place near a pond or stream where they are not in danger of frost.

So these are some animals that cannot find food during the winter. Some of these animals are warm-blooded and some are cold-blooded. Those that cannot find food in any way are usually hibernators.

THINGS TO THINK ABOUT

1. Think of all the changes that go on among plants and animals as the seasons change.

2. Do you see how living things are affected by the sun's light and heat energy?

3. Think of how different everything would be if the earth were not tilted on its axis!

THINGS TO DO

Get a frog or a garter snake. Keep it indoors in some sort of box or cage. Put some earth on the bottom of the cage. Put some plants and water in the cage to make it as much like the place where you found the frog or snake as you can.

As cold weather comes, place the box in a cool place. What does the animal do when it is cold? What does it do when it is warm?

V

Cause of Climates

CLIMATE IS NOT THE SAME EVERYWHERE

SOME PLACES ARE NEARER
THE EQUATOR THAN OTHERS

SOME PLACES ARE BOTH COOL AND WARM

SOME PLACES ARE HIGH
IN THE MOUNTAINS

SOME PLACES ARE NEAR OCEANS,
SEAS, OR LAKES

MOUNTAINS AFFECT CLIMATES

ARCTIC CIRCLE
Juneau 42.1° F.
Vancouver 49° F.
Spokane 48.2° F.
Salt Lake City 51.6° F.
Sante Fe 48.8° F.
Albuquerque 55.3° F.
Monterrey 71.2° F.
TROPIC OF CANCER
Mexico City 59.6° F.
Veracruz 76.6° F.
San Salvador 74.7° F.
COOL
Ancon 80.2° F.
Quito 57.2° F.
EQUATOR
HOT

DID you know there are deserts at the south pole? Did you know it is so cold in some places on the equator that people wear coats all year round?

Climates do not change from day to day as weather does. Because of this, people can depend on the places where they live having about the same climate for very long periods of time. They know that they can wear about the same kind of clothes from year to year; they can raise about the same kind of food from year to year.

The little white triangles on the map on page 117 show where high mountains are located. The numbers show the average yearly temperature of each city. With the help of this map, perhaps you can answer this question: "Why do some of the cities north of the equator have a warmer climate than Quito, even though Quito is so near the equator?"

It takes a long, long time for climates to change. Once, many ages ago, tropical plants grew in the arctic. At another time a great ice sheet covered the northern part of North America.

What are the different climates, where are they, and what causes them? The next story may help you to understand some of these things.

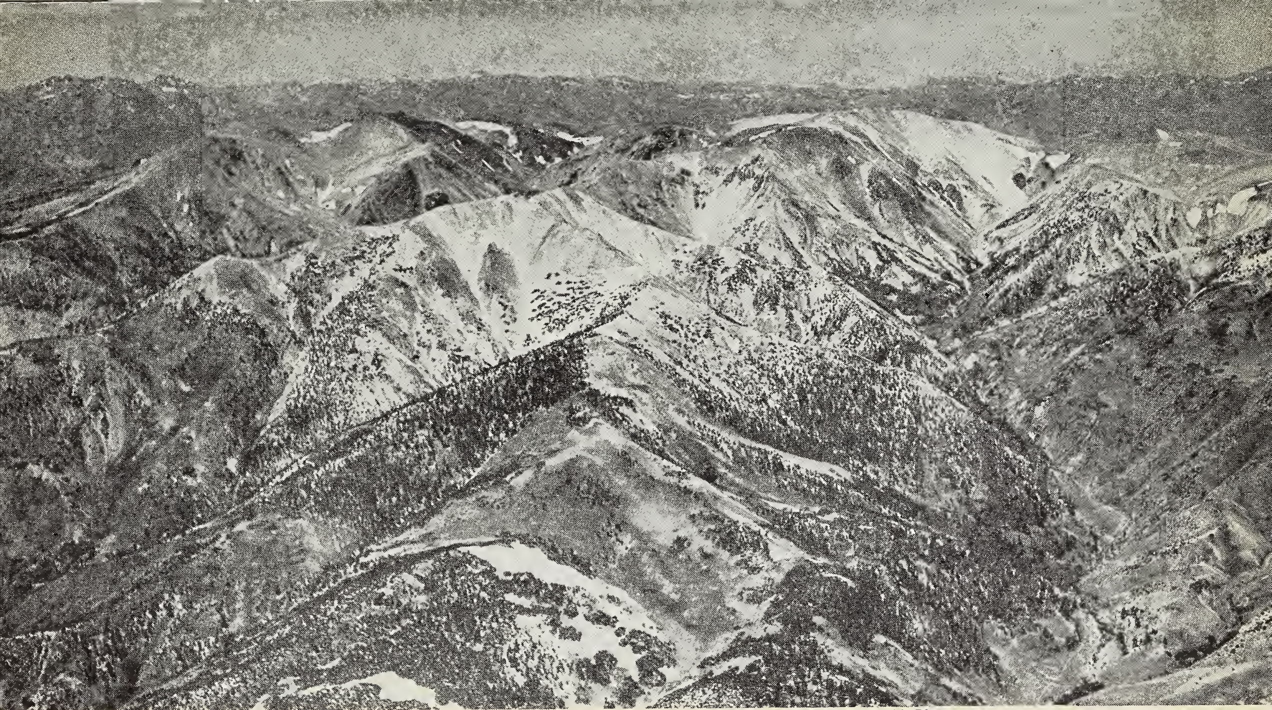
Climate Is Not the Same Everywhere

Suppose we take an airplane trip across the United States. Let us imagine we are flying almost straight across the continent from Washington to San Francisco. The time is January. In Washington the temperature is about 36° F. The sky is clear and sunny. We fly on to Cincinnati. It is warmer here—about 42° F. Kansas City is still warmer. The thermometer reads 46° F.; but here it is raining hard.

Next comes Denver. It is much colder here. There is snow on the ground. People wear heavy clothing. Children dressed in warm snow suits are enjoying sledding and skating. The temperature is 24° F., and it is growing colder.

Our airplane goes up and up. We are flying over the snow-covered Sierra Nevada. In fact, the snow is ten feet deep in some places in the higher mountains. There are few houses in this region. All we see is white mountains. On the western slopes of the mountains we find people enjoying skiing and other winter sports. It is very cold here. There are few real cities. Small villages are built for the winter-sport trade.

In a few hours more our trip is ended. We have reached San Francisco. What a different scene! It is a clear, sunny day, and the thermometer reads 48° F. There is no snow here. Children are roller-skating and playing tennis. Their wraps are sweaters or light coats. Many of them wear no hats.



Spence Air Photos

Would you like to live in the Sierra Nevada?
What do you think the climate is like in the winter?

But these people who live in San Francisco may also enjoy winter sports. This is because they can travel up the mountains from the warm winter climate of San Francisco to the cold winter climate of the Sierra Nevada in a few hours. Should you like to live in a warm climate and enjoy winter sports over the week end?

All these cities are north of the equator and are having winter at the same time. They will all have summer at the same time. All places north of the equator have winter from December to March. All places south of the equator have summer from December to March.

But is winter the same in every city north of the equator or in every city south of the equator? Is San Francisco as cold as Chicago in the winter? Will Denver be as warm as Miami in the winter?

We know that different places have different temperatures even during the same season. However, we may think of some parts of a country as being warm most of the year. Some such places are Florida and the southern parts of California and Texas. Here we do not often find any snow. Even during the winter, people enjoy swimming and sun bathing. These states are famous for their warm winters.

Some parts of North America may be cool all year long. Maine and Vermont, British Columbia and Quebec are such places. They have wonderfully cool summers. People come from many parts of North America to spend their summers here. In the winter people also come here to spend their vacations. But this time they come for the winter sports. They ski, ice-skate, and

take sleigh rides in the snow-covered hills and mountains of these northern states and provinces.

Then other places, such as Death Valley, may have little or no rain. Still others may have about equal amounts of rain, heat, and cold.

We say that all these places have very different climates.

SOME PLACES ARE NEARER THE EQUATOR THAN OTHERS

You would expect some places to be much warmer than others because they are nearer the equator. The equator is in the center of the tropical zone. We know that the part of the earth within the tropical zone receives much heat energy. It also receives much light energy from the sun.

What are some of the hottest places you can think of? Perhaps you know some of the following names: Singapore, Habana, Bombay, the Sahara Desert. Can you locate them? Ask your teacher to help you if you cannot find all these places on a globe or on a world map.

How near to the equator are they? Of course you may not be able to tell their exact distance from the equator. That does not matter, since we do not need to know their exact distance. Are all these places within the tropical zone?

Singapore, Habana, and Bombay are warm all year long. Their winters are a little cooler than their summers, but they really never have a cold winter.

R. Moulin, from Galloway

This boy lives near Macassar.

Why do you think the climate of Macassar is warm

Some hot places have little rain. Such places are called deserts. It is very difficult for man to live in desert regions. He has to depend on the outside world for food. Our ordinary food plants cannot grow in such dry regions.

Other hot places have a great deal of rain. Plenty of food grows there. However, it is very difficult for man to live in such a hot, moist climate. It is too hot to do much work. There are a great many insects. Man is very uncomfortable in these regions.

Then some places are cold all year. Can you locate Point Barrow, Little America, Baffin Land? Again you might need your teacher's help. How far from the equator are they?

So far as we know, there are no natives of Antarctica. This southern land is covered with snow and ice. Do you know what animals Admiral Byrd and his men did find in Antarctica?

These cold places are a long distance from the equator, are they not? We say that they are the north and south polar regions of the earth.

This boy lives on Cape York in Greenland.
Could you give a reason for the cold climate of his country?

© Captain Bartlett, from Gendreau

During the long winters they receive little light or heat energy from the sun. Of course in the summer they do receive more light and heat. But the direct rays of the sun never reach the polar regions. You know that these slanting rays do not cause so much heat as direct rays.

So there are places on the earth which are cold all year long because they are so far from the tropical zone that the sun's rays never shine down directly on them.

SOME PLACES ARE BOTH COOL AND WARM

Many people live in countries which are cold part of the year and warm part of the year. We say that they live in the temperate zone. Can you find Arizona, Kansas, South Carolina, Ontario, the British Isles, Poland, and China on your globe? All these places are between the tropical region and the north-polar region.

Now find Australia, Argentina, and South Africa. Parts of all these countries are between the tropical region and the south-polar region. What kind of climate should you expect them to have?

We say that all the places between tropical and polar regions are in the temperate zone. That means that these places are not too hot and not too cold.

Now locate the central part of North America on your globe. Beginning at the equator, move your finger northward toward the central part of the United States until you come to New Orleans. This city is on the Mississippi River, is it not? Now move your finger

Helen Hultz

Are your shadows as long as this at noon on August 3?
Do you know why this happens in Greenland where this picture was taken?

northward along the river. Do you see Memphis, St. Louis, Madison, and Duluth? Memphis and St. Louis are on the Mississippi. Madison and Duluth are not far from the river. You would expect the cities to have a colder and colder temperature as you went northward.

Let us see if this is true. New Orleans has an average yearly temperature of about 69° F. Do you know what an average temperature is? This means that the temperature throughout each day of the year is added to the temperature for every other day of the year and that the sum is then divided by 365 or 366. Why divide by 365 or 366?

This boy lives in the northern part of the United States.

The winters are cold her

Kaufmann-Fabry

McManigal

This boy also lives in the northern part of the United States.
The summers are warm here

You might find another average. Do you know the average age of the children in your room? It is probably between ten and eleven. Can you find the average weekly temperature of your room? Ask your teacher to help you with this.

Here are the average yearly temperatures of the other cities:

Memphis	62° F.
St. Louis	56° F.
Madison	45° F.
Duluth	38° F.

Fairchild Aerial Surveys

Mexico City is in the mountains high above the sea.

This city has a delightful climate all yea

SOME PLACES ARE HIGH IN THE MOUNTAINS

Many times men who live in the tropics build their cities in the mountains in order to escape the heat of the lowlands.

Mexico City is about a mile and a half above sea level. Many people do not know this. They think that it has a tropical climate because it is so near the equator.

Companies who advertise Mexico City as a delightful place to visit spend a great deal of money telling people that Mexico City is cool even though it is in the tropical region.

We can say, then, that the height of a city above sea level has a great deal to do with its climate.

SOME PLACES ARE NEAR OCEANS, SEAS, OR LAKES

What do you know about the people and the climate of the British Isles? Have you ever thought just how far Great Britain is from the equator? If you look on a world map, you will see that it is much farther north than New York City or even Nova Scotia; in fact, it is just about even with Labrador.

Have you ever heard how cold it is in Labrador? Eskimos live in Labrador. Perhaps you know some other things about this country.

It is true that these two countries are the same distance from the equator, but there is a great difference in climate. The average yearly temperature of Glasgow, Scotland, is about 47° F. The average yearly temperature of Hebron, Labrador, is about 23° F. This is a difference of 24 degrees. Yet Hebron and Glasgow are about the same distance from the equator. Do you not think this is a strange thing?

Perhaps you think that one of these places is built on a mountain and that this explains the difference in average temperature. But if you will look at a map or

globe which shows mountains, you will see that both places are about the same height above the level of the sea. So there must be some other reason to explain this difference in climate.

Scientists who are interested in climates tell us that there are many things which make a place have a certain type, or kind, of climate. The nearness to a large body of water is very important. By a large body of water we mean oceans, seas, and lakes. Sometimes a place has a warmer climate because of the water. Sometimes its climate is colder.

The difference in the climates of Labrador and the British Isles is caused by currents in the Atlantic Ocean. From the Gulf of Mexico between Florida and Cuba flows a warm ocean current. It is called the Gulf Stream. It flows northward along the Atlantic coast. Then it swings northeastward toward the British Isles.

The winds blowing toward the British Isles are warmed by this current and make the climate of England, Scotland, and Ireland warm.

If you ever sail down the Atlantic coast from New York City to Miami, you can see the Gulf Stream. The Atlantic Ocean seems quite green when you leave New York City. About halfway to Miami the water becomes more and more blue until it looks as blue as the sky. You have entered the warm Gulf Stream.

Perhaps you will not be surprised to know that the cold climate of Labrador is also caused by an ocean current. But this current is entirely different from the warm Gulf Stream. Along the coast of Greenland and

The broken arrows show the direction of the Labrador Current and the solid arrows show the direction of the Gulf Stream. Do you see why Hebron has a cold climate and Glasgow has a warmer climate even though they are about the same distance from the equator?

southward along the Atlantic coast of North America moves a cold current. We call it the Labrador Current. This ocean current begins in the Arctic Ocean on the west side of Greenland. So you know it must be really cold water. Winds blowing across the icy waters of this current cause very cool summers in Labrador.

This current also affects the climate of Greenland. We said that the Labrador Current flows down the west coast of Greenland. The current makes the western coast of Greenland so cold that there are only a few villages there.

As you know, Greenland is always covered with a great sheet of ice called a glacier. It is very difficult to cross overland from coast to coast. Since you cannot go overland, the only way to travel is by boat.

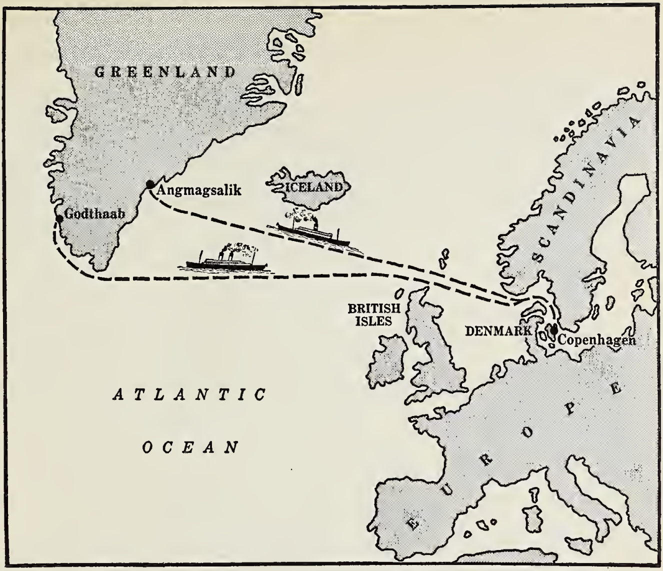
Boats travel up the west coast of Greenland. But very few travel up the east coast, since so few people live there. In fact, about the only boats which sail to the east coast are those from Denmark. These boats travel from Denmark to Greenland and back again to Denmark.

There was a man living on the east coast of Greenland who wanted to visit in a village on the west coast. Of course he could not travel overland because of the glacier. No boat sailed from his village around the tip of Greenland to the west coast. So the man had to make a very long journey to get from one village to the other.

He sailed from the east coast all the way to Denmark. Then he had to change to another boat and sail from Denmark to the west coast of Greenland. How do you suppose he got back to his home village?

So, you see, climates affect the settling of a country, its trade, and the lives of the people who live there.

There are other cities and countries which are affected by oceans, seas, or lakes. California, Oregon, Washington, and southwestern Canada have a mild,



This map shows the journey that a man made from the east coast of Greenland to the west coast of Greenland. Can you tell why he had to do this?

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pleasant climate. This is because breezes blow over the coast from the Pacific. As these winds always blow from west to east, they always bring moisture to the west coast of North America.

Water has another effect on climate, too. Scientists tell us that water heats slowly and keeps its heat a long time. In fact, it heats much more slowly than land, and it keeps its heat much longer than land. So a city near water would not have so cold a winter as a city which is far from a great river, lake, or ocean. The inland city

would lose its heat rapidly, since it is not near a large body of water. It would gain heat more quickly in the summer than the coast or lake city.

Then, too, the coast city would have a cooler summer, because the water heats up very slowly. The inland city which is surrounded by land would have a much warmer summer, because the land by which it is surrounded heats up quickly.

So we can say that coast cities have a more steady climate than inland cities. The places in the central part of the United States have cold winters and hot summers. They are not near large bodies of water as a rule.

MOUNTAINS AFFECT CLIMATES

Of course moisture in the form of rain helps to make a moist climate. Winds carry the moisture over the land. As long as the winds can blow across a land evenly, there will be a moist climate. But sometimes winds cannot blow steadily and evenly. When this happens, they often lose their moisture. This very thing happens in the United States.

We said that the winds blow from west to east across the United States. They have plenty of moisture as they blow in from the Pacific across California. But then the winds must blow across the mountains. They must cross the high Sierra Nevada, and as they do so they must rise. When the winds rise, they become cooler and cooler. The air finally becomes so cool that it loses all its moisture in the form of rain.

Dick Whittington

California has warm winters and cool summers. Do you know how the Pacific Ocean affects the climate of California?

Much rain falls on the Pacific side of the Sierra Nevada. When the winds finally get over the mountains, they have lost a great deal of moisture. As they blow across the land, they carry no clouds for a while. So on the east side of the Sierra Nevada we find the Great American Desert. Because of the mountains, little rain falls on this part of the United States.

By the time these winds reach the central part of the United States, they again have enough moisture to cause rains in the central and eastern states. Mountains, then, are sometimes the cause of dry climates.

So we see that there are several reasons why a certain place will have a certain climate. The coast of California has a pleasant, mild climate because of the winds from the Pacific Ocean, the mountains to the east, and its distance from the equator.

All such things as mountains, water, and distance from the tropical zone help to make the climate of any place on the earth what it is.

THINGS TO THINK ABOUT

1. There is a city, Guayaquil, built at the base of the mountain on which Quito is built. These two cities are about the same distance from the equator. Yet the people of Ecuador say that Guayaquil has a very unhealthy climate, because it is so hot and moist. Quito's climate is more healthy, because it is cool all year long.

Being near to the equator, then, does not always cause a place to have a very hot climate.

2. Suppose that three fourths of the earth's surface were land and one fourth water. What change would you expect in climates?

THINGS TO DO

1. Plan a trip to take in the summer in the tropics. Where could you go and be cool except when you were traveling from place to place?

2. Locate Italy on a world map. Do you see the great mountain range, the Alps, to the north of Italy? Can you tell why Rome and New York City, which are about the same distance from the equator, have such different climates?

VI

Climates and Living Things

WARM, DRY CLIMATES

COLD CLIMATES

WARM, MOIST CLIMATES

TEMPERATE CLIMATES

LIVING things are found all over the surface of the earth. There are plants and animals in the forest and the desert, in the sea and on the mountaintops, at the equator and in the polar regions.

But the kinds of living things we find in these places are often very different. Coconut palms do not grow in a cold, dry climate, while fir trees do not grow well in a warm, moist climate.

Yet some of the largest violets and cabbages in the world have been grown in arctic regions.

Much of the land part of the earth is used by man for raising food. It has not always been easy to make the land ready for farming. The picture on pages 142 and 143 shows land on which orange trees are growing. It was good land but it had to be irrigated. But even with irrigation oranges could not grow here if the climate were not warm the year round.

In this story you can find out more about the different kinds of climates and especially about the plants and animals which live in these different climates.

Spence Air Photos

This is a desert in the United States.

Would you like to try to live in this desert?

Warm, Dry Climates

A TRIP OVER WARM, DRY LAND

Imagine that we are traveling about the world by airplane. At some time or other we probably pass over land much like that which you see in the picture of the desert. Of course you immediately say that we are flying over dry land. And so we are—over hot, dry desert land.

As we fly along we notice that the land looks quite dull. There are no tall green trees, only pale green bushes. There are no cities or villages in this dry region. It is difficult to breathe the hot, dry, dusty air. The only movement on the desert seems to be that of the dust which is being blown about by the wind.

Then in the distance we see a small, black moving object. As we come nearer, we see that it is a moving automobile. The people in it are crossing this desert as rapidly as they can. It is not very difficult to cross the Great American Desert in an automobile today. But you may be sure that the traveler has plenty of gasoline, oil, and water before he starts on his journey. There are few gasoline stations scattered along the highway.

Now suppose we find ourselves above the Sahara Desert in our airplane. This desert is almost as big as the whole United States. The journey across the Sahara is difficult. Camels are still used to carry men and goods across the desert, although some people use automobiles. Sometimes it is necessary to stop the journey in the middle of the day because of a great sandstorm.

Royal Air Force (official photograph, crown copyright reserved)

The Nile flows through a desert. During flood time it waters much of the desert land so that people can grow plants there

There is another difficulty which desert travelers must face. This is the change in temperature from day to night. As soon as the sun disappears, the air becomes quite cool and sometimes even cold.

Suppose we continue our journey. Once in a great while we notice a bright patch of green plants. Here there are trees. Why do you suppose trees are able to grow in the middle of the desert? Of course there must be water. Sometimes the water flows across a part of the desert and makes an entire valley fertile. The Nile River does this. It makes the fertile Nile Valley. But most of the time in the midst of a desert there is only a spring or a well which gives enough water for the growth of larger plants.

How many deserts are there on the earth? Can you locate some of the hot, dry regions of the world? Look for deserts in these places:

Southwestern United States
Northern Africa
Central Asia
Southern Africa
Western South America
Australia

THERE ARE MANY PLANTS IN THE AMERICAN DESERT

Do you usually think of all deserts as great stretches of sand with no plant growth? If you have traveled in Arizona, you know that this is not true. There are plants

on the Great American Desert, but these plants are not like those we see on farms or in forests or meadows.

Look at the picture of the desert again. Notice the low bushes. Do you see any trees at all? No, the tallest plants on the desert are such plants as cactus, greasewood, and sagebrush. But just how can these plants grow in a place where there is very, very little rainfall and where the thermometer has gone up to 134° F.? You would think that all plants would wilt and die at this temperature.

If you could take a closer look at these plants of the desert, you would notice that the sagebrush has tiny leaves, while the cactus plants have only spines for leaves. Small leaves are most important if these plants are to live in such a dry climate.

Plants with such small leaves and thick skin cannot lose much water even if it is very dry. There is not much leaf surface from which the water may evaporate. Some types of cactus plants lose so little water that thirsty desert travelers have found water stored in the stems.

Such plants as these have long, tough roots that grow far down into the soil until they reach water. They cannot depend on rainfall for their water supply. So they must have roots which reach down into the soil, and stems which store the water.

These desert plants are grayish-green in color and are covered with dust. So the desert almost always has a dull, dry look. However, at times it is brilliant with color.

One of these times is when the cacti and sagebrush are in bloom. The flowers of the gray sagebrush are small and purple. But the flowers of the cactus plants are large and bright. The blossoms are many shades of red, yellow, orange, and purple.

The other time that the desert is brilliant with color is just after one of the few rains. Then small plants grow up very rapidly from seeds which have been lying on the soil for a long time. These little plants have very delicate stems and leaves. Their roots do not grow deep into the soil; they spread out just under the surface of the soil, so that they absorb as much water as possible.

The flowers of this evening primrose, which grows in a desert, are closed tightly during the day. Why do you think this happens?

H. L. Jones

Keystone

It is hard to walk across the sand of the Sahara Desert.
Would it be easy to build a railroad across this desert?

In a few weeks these plants have large, beautiful flowers. The plants make seeds, which fall to the ground and stay there until another rain falls. Then these seeds sprout and grow very quickly.

As long as there is any moisture in the soil these small bright plants will bloom. But as soon as all the moisture has dried out of the topsoil, the plants die.

If all the small flowering desert plants should die before the seeds were made, then there would be no more of these plants.

THERE ARE PLANTS IN THE SAHARA

As the Sahara Desert has little plant life, the sand is blown about by the winds. Have you ever read about the great sandstorms on the Sahara Desert? It would be very difficult for seeds to grow on this moving sand even if they had enough water.

However, there are some places in the Sahara where plants do grow. These are the oases. Do you know what an oasis is? It is a place in the desert where plants grow and animals can find water and shade. It is cool and restful after traveling in the hot desert sun. Imagine

Where do you suppose the water in this oasis comes from?

Galloway

how the people in the desert caravans watch and wait for the sight of these green spots!

If you stop to think what it means to travel mile after mile across the burning sands, you will begin to understand how welcome the bubbling spring water, the green grass, and the leafy trees are to the travelers. These men carry their water in skin bags strapped to the camel's backs. The water becomes warm and is not so good as it is when it is cold. Still the men drink it because they could not go on living without it.

A story is told of a wealthy diamond merchant who crossed the desert with many thousands of dollars' worth of precious stones. While crossing, his caravan got lost. They wandered about for days seeking an oasis. The supply of water became very low and at last there was no more. Still there was no oasis in sight. Just as they were about to give up hope, they saw another caravan. The wealthy man was so delighted that he paid in diamonds for the water which was given him.

If an oasis is large enough, there may even be people living there all the time. This is true of only a few places. Most oases are too small to shelter a village.

Man has also caused plants to grow in some desert regions. The Imperial Valley of California would be desert land if it were not for the Colorado River. Man has made use of this river in irrigating the land. The people who live in this valley are able to raise many fruits and vegetables which usually grow in warm, moist climates because they have dug canals, or large ditches, to bring the water to the place where it is needed.

OTHER LIVING THINGS OF THE DESERT

There are other living things besides plants in the deserts. As we fly along over this dry land, we see only a few animals, since most of them hunt for food at night. Those that do hunt food during the day usually stay in the shade of the bushes.

Many of the animals that live in and near deserts have the colors of the bare rocks and soil around them. They are usually dark gray and brown. Bright colors would soon bring danger to many of these animals.

If you have ever driven across the American Desert, you have probably seen great numbers of rabbits. These animals feed on plants. Do you know any other animals on the desert which feed on plants?

But many desert animals feed on other animals. Can you name some of these other animals? You have probably already named snakes and coyotes. There are also birds which live on the desert. Some owls and vultures are desert birds. Small desert wrens make their nests in cactus plants. Where do you suppose these animals get their food?

The dry, hot climate of the desert is not good for most living things; so we do not find a great many different kinds of plants and animals in the region. If man lives in a desert, he must live near a source of water. Even if he does this, he may be uncomfortable because of the great heat. This is also true of many of the animals.

Is it not a good thing that more of our climates are not desert climates?

United States Forest Service

It would be hard to find this desert rabbit because its color is much like that of the groun

THINGS TO THINK ABOUT

1. In the Sahara Desert the thermometer may read 99° F. during the day and 31° F. at night. Such a change in temperature makes it necessary for travelers to wear special clothing.

2. Because there is little water, there are no clouds and little plant life; so the desert sands become very hot during the day. At night the sand cools very rapidly. The air also cools quickly.

3. Plant life and water vapor help to keep many climates from having hot days and very cool nights.

THINGS TO DO

1. Here is an experiment that may help to show you how plant life holds moisture in the soil and keeps it from becoming very hot.

You will need two small flat pans. Fill one pan with dry sand. Into the other put other soil on which moss and other small plants are growing. Water the soil well so that the plants will not die.

Put the pans outdoors in the sunshine. Every hour test the two kinds of soil for temperature. Feel the top of the soil with your hand and measure the temperature with a thermometer. Keep a record all through the day.

Do you see why bare desert soil gets so hot?

2. Make a desert garden. If you live where it is warm you can make it outdoors; if not, make it in a large box indoors.

How much sunlight will your garden need? How often should you water it? What kind of soil should you use?

What kind of plants will you use in your garden? What kinds of small animals should live in it?

Byrd Antarctic Expedition

There are no plants growing on this cold desert in Antarctica

Cold Climates

ARCTIC AND ANTARCTIC DESERTS

The warm, dry deserts of Africa, Australia, Asia, and North America are not the only deserts on the earth. There is much desert land in the polar regions.

Perhaps you are wondering how this can be true since we know these places are cold. Do you really know what the word *desert* means? Look up its meaning in a dictionary or in the word list of this book. You can see from these explanations that any place with few living things is a desert. So some deserts are cold and some are very warm.

Can you tell why so few plants grow in polar regions? Of course you will probably say it is because of the great cold. This is true. For a month or so the temperature will be above the freezing point of water in some parts of the polar regions. But even in the middle of the summer a frost may kill some plants. In the winter everything is frozen. We should not expect to find plants growing then.

It is true that some animals live in polar regions. Reindeer, musk oxen, and rabbits are able to find plant food even in the winter. However, most of the other animals, such as wolves and foxes, which live in the cold climates are meat-eaters.

We are told that not more than 75,000 people live within the Arctic Circle. Find all the land within the Arctic Circle on your globe. Do you not think that this

is a great deal of land for 75,000 people to live on? Find New York City on your map. More than one hundred times as many people live in this small spot.

But what about the south-polar region? So far as we know, not one person lives on the great antarctic continent.

These polar regions, then, are really cold deserts with few plants and animals living there.

WINTER IN THE ARCTIC

We should find it very uncomfortable to spend a winter in the north-polar region. In the first place, we should live on the frozen sea unless we were very near the north pole. There is much less land around the north pole than around the south pole. However, we could spend our winter in the northern part of Asia or North America, and still be within the Arctic Circle.

In all places within the Arctic Circle which we might visit we should discover one thing to be the same. There would be no sunlight all winter long. Yet this winter darkness is not so black as you might think. Brilliant stars may always be seen. Perhaps you say that this is also true in the place where you live any time; yet the night seems very dark to you. But remember that the arctic regions are white with ice and snow. This white covering of the land reflects all the light of the stars and moon; so the arctic winter is not one of inky blackness. It is a soft twilight, which is quite bright enough so that you can see objects about you fairly clearly.

But should you like to live in this twilight for months? The light of the sun would not be the only thing you would miss; you would also miss its heat. The land becomes colder and colder all through the winter, because the earth is giving off a great deal of heat and no heat is coming to this part of the earth from the sun.

Of course we know very little about life on the ice cap at the north of the earth. Arctic life is not found so far north. However, life is found in the northern parts of Asia, North America, and Greenland in the winter. These parts of the arctic regions are said to have a tundra climate. The tundras, or treeless plains, are not always covered with ice and snow. In fact, some of the ice and snow melts during the short summers.

The natives who live in the tundra regions do not use only plants as their food. This is especially true in the winter. They eat the flesh of the reindeer, or they use fish, seals, and whales as food.

SUMMER IN THE ARCTIC

At noonday in the middle of January the southern part of the sky becomes rosy at the north pole. Each day at noon this brightness increases until part of the sun appears for a few minutes on February 21.

Even though the sun does not set for four months after the middle of April, the summer is not very warm. It would take a long, long time to melt all the ice and snow. Ice and snow never disappear on the arctic ice cap and in the central part of Greenland.

Donald B. MacMillan

This child lives only 700 miles from the north pole. It is warm for only a few weeks in the tundra regions

But what is summer like in the tundra regions? In most of these regions the summer lasts at least two months and sometimes four months. The natives live in tents made of skin during the summer. They can move these tents from place to place as they hunt and fish. As the summer days are quite cool except at midday, the natives must wear much more clothing than we wear at that same time of year.

Most of the plant life of the tundra regions, or cold deserts, grows close to the ground. Many of the plants are small like moss. There are also flowering plants in these regions. Such plants must grow and produce flowers and fruit in less than two months. This is necessary because they cannot continue to grow after a killing frost, and there are such frosts, except from the middle of June until the middle of August. Can you imagine living in a place where all the plants grew and blossomed within two months? There would be no large trees, wheat, oats, corn, cotton, or any other plant which has a longer growing season.

Many of the arctic plants have blossoms of very brilliant colors. So the tundra regions are quite beautiful at times.

During the arctic summer many birds, such as golden plovers and arctic terns, appear from the south. They build their nests and rear their young here in the tundra regions. Such animals as bears, wolves, and foxes become more active. Reindeer and musk oxen find food more easily. Some of the foxes and rabbits change from white to gray or brown in color. In very wet regions mosquitoes and stinging flies are thick. Man must move to higher and drier ground in the summer.

But the arctic summer is a short one. Ice begins to form on some of the lakes during August. Plants are frozen. Birds have already started on their journeys southward. During August the sun begins to go down for a few minutes each day. By the end of September there are twelve hours of darkness. Soon the sun disappears and is not seen again until February. The long, cold arctic winter begins again.

LAND OF JUNE WINTERS

Perhaps the greatest desert in the world is the one surrounding the south pole. The great antarctic continent is covered with a sheet of ice and snow many feet thick.

Along the edges of this great continent we find some animals. These are chiefly birds which are able to find food in the sea. There is also some plant life there.

Byrd Antarctic Expedition

This picture was taken during the warmest months in Little America. What month do you think it might have been

But no people live on this deserted continent. You know that it is only within the last few years that man has explored successfully in this region. It is true that Admiral Byrd and his men spent many months in Little America. However, even they could not do much exploring during the long, cold winter. Most of their explorations were made from December until April.

Much of the antarctic continent is yet to be explored.

It will be interesting to watch for explorations in both the south and north polar regions. Perhaps some day these regions may be of great use to us. But at the present time, such cold climates with little plant or animal life are of little use to us.

THINGS TO THINK ABOUT

We can see how much we depend on light and heat energy from the sun. Even though we can use electrical energy for light and the energy from coal, oil, and wood for heat, we should have to have heat and light a much longer time for a house in the polar regions during the long, cold winters.

THINGS TO DO

This experiment may help you to see how the earth is tilted so that the arctic regions have a long, cold, dark winter.

Draw a circle on the floor about five feet in diameter. Let one child stand in the center with a flashlight to represent the sun. Put the earth globe on a chair and move the chair around the circle. Keep the north pole *always* pointed toward the north.

As you move the globe slowly around the circle, you see that part of the arctic region begins to have light about February. By the end of March all the arctic region has day for twelve hours and night for twelve hours. From about April to August it is light all the time. This is the summer season.

Is it any wonder that the arctic is covered with ice? The sun's heat and light energy does not reach this part of the world for several months of the year.

Warm, Moist Climates

REGIONS WITHOUT COLD WINTERS

There are places on the earth which have no cold winters, just as there are places which have no hot summers. Most of these regions are within the tropics, or else they are very close to the tropics. Here is a short list of some of the cities in such regions. Can you make it into a longer list?

Habana, Cuba
Pará, Brazil
Rio de Janeiro, Brazil
Dakar, India
Singapore, British Malaya
Manila, Philippine Islands

Of course some of these places are colder during the winter months than others. Habana has a slightly colder winter than Singapore. Can you tell why? But none of these places have seasons of cold and heat. The temperature stays about the same all year long.

Let us think for a moment just what it would be like to live in a city which has a warm climate all year. First of all, we should not have to worry about summer clothes, fall clothes, winter clothes, and spring clothes. We should wear the same kind of clothing all year. Of course a very light coat might be useful at times, but a raincoat would be much more useful than a heavy woolen coat. Our houses would need no large fireplaces or furnaces for heating.

As for food, we should have fresh fruits and vegetables every month in the year. There would be no very cold weather to keep us from having a garden. There would always be flowering plants. It would be necessary to see that the plants had plenty of water, for the hot sun would cause evaporation to take place very quickly.

What fun we should have playing games! It would never be too cold to go swimming. Tennis and baseball would always be in season. However, it would be best to play such games in the morning or late afternoon. Early afternoon is usually very warm in such regions, and people like to take a rest until three or four o'clock.

But you would have to put all thoughts of sledding, skiing, and ice-skating out of your mind. It would be most difficult to have such sports in this region.

Perhaps you are wondering just why there is no cold winter in the tropical regions. If you remember the experiment on seasonal change, you know these things. Direct rays of the sun give the most heat and light energy. The earth in traveling about the sun is so turned that these direct rays always shine on the part of the earth between the tropics of Cancer and Capricorn. In other words the central part of the earth is never turned away from the sun at any season.

So we should expect this part of the earth to be warm all year long even in the winter months.

Sawders

Many of the villages in Brazil are on rivers.
The natives of this village on the Amazon travel mainly by boa

RAINY REGIONS

The people in the tropics do not use the names *winter* and *summer*. They call their seasons the dry and rainy seasons. In some of the tropical regions, the two seasons might be called the rainy season and the less rainy season. The Amazon River of South America flows through just such a climate.

At the mouth of this river is Pará, Brazil. The climate here is like that of other regions of much rain. Pará has an average of about 13 inches of rain for the month of March. Compare this record with the rainiest months of the following cities.

New York City . .	4.3 inches in August
Charleston . . .	6.5 inches in August
Santa Monica . . .	3.5 inches in January
St. John's	6.3 inches in January

Perhaps you can see now how much rain must fall in Pará during March to give an average rainfall of 13 inches. It would very likely be more than twice as much as falls in the rainiest month where you live.

In Pará there is a rainfall of 2.3 inches in the least rainy month. So you see the "dry" season there is not really dry. It may be as wet as the rainiest month in your city.

All along the Amazon we find the tropical rain forests. Suppose we could explore the Amazon and some of the streams which flow into it. This great river is so deep that ocean vessels can travel over a thousand miles up the river.

Let us travel up one of the many streams which flow into this great river. No matter what time of year it is, the plants along the banks are always green, since there is no cold winter or very dry season. Vines form a curtain from the treetops to the water's edge. We wonder if we shall ever be able to find our way into the jungle. However, when we do go into the dense forest, we find few small bushes or trees. Blooming vines grow to the tops of the trees, so that they receive as much sunlight as possible.

The trees are tall and straight. There are few branches near the ground, but many near the tops of the trees. Sunlight does not often reach through to the forest floor.

If we start our trip in the early morning it will probably be clear. About noon we have to seek shelter in a village because huge rain clouds begin to gather. In the early afternoon the storm begins. All at once the rain seems to crash down. Trees and vines bend this way and that. There is lightning and thunder. Suddenly the storm stops.

A sudden storm of this type is common in the tropics. A slow rain which lasts for many days is rare in this region.

As you might expect, there is much animal life in the tropical rain forests. There are not many large animals roaming the floor of the forests because it is difficult for them to find food there. The greatest amount of food is in the treetops where animals find the fruits of the trees and vines.

Black Star

There are so many plants in the Amazon jungle that it is dark even at noon

Of course we find many different kinds of birds and climbing animals such as monkeys. There are also snakes, alligators, and toads near the streams. But we find more insects than any other kind of animal. There is always a hum of insects in the tropical rain forests.

Plant and animal life is always abundant in these regions. This is one region on the earth where there is enough rainfall and heat for all plants to grow all year. Because of this there is always food for animal life.

However, in this land of summer man finds it difficult to live. It is easy for him to find food. In fact, someone has said that here man is only a food-gatherer and not a food-grower. If this is true, why is it so hard for man to live here?

First of all, it is not easy to cut through the forests; so the villages of this region are usually found along streams. It is possible to travel by boat from one village to another, but it is very hard to travel through the forest. The houses of these villages are built on stilts, because the ground is always moist and even flooded during the rainy seasons. The moist, hot air of the forests is very uncomfortable; so the houses must be well ventilated.

Perhaps the chief reason why many people do not live here is the presence of so much disease. Insects of the rain forests carry such diseases as malaria and sleeping sickness. We hope that some day man will really be able to conquer tropical diseases. Then he may be able to live in the tropics more comfortably and more safely and make more use of the great amount of plant and animal life there.

So even though there is plenty of food in the tropical rain forests, you and I should find it hard to explore there and almost impossible to live there.

THINGS TO THINK ABOUT

1. Imagine how difficult it must be for men to explore the dense rain forests. They have to travel much of the way in boats or else cut their way through the forests. Pure water must be found and carried in the boats. Medicine is very necessary to fight disease. Shelter from the daily rains must be found.

2. How do you think other climates have affected man's explorations on the earth?

THINGS TO DO

1. Can you explain why there is so little difference between the average monthly temperatures of Habana and Singapore?

	Habana	*Singapore*
January	71.6	78.3
February	72.5	79.0
March	74.3	80.2
April	76.8	80.8
May	78.8	81.5
June	81.5	81.1
July	82.4	81.0
August	82.2	80.6
September	81.1	80.4
October	79.0	80.1
November	75.6	79.3
December	72.5	78.6

2. Find the average monthly temperatures for a city in the temperate zone. How would you explain the greater difference between summer and winter temperatures?

Temperate Climates

PLANTS AND ANIMALS

Temperate climates might be called in-between climates. They have warm summers and colder winters, rainy seasons and less rainy seasons. However, we have discovered that these seasons are not exactly the same everywhere in the temperate regions.

Summers in Oregon are different from summers in Georgia. Winters in Arizona are different from those in Alberta. Rainy seasons are of different lengths in each of these places, and the amount of rain that falls in each region is different.

If you look on your globe you will see that the temperate zones, or regions, lie between the tropics and the polar regions. In the northern temperate zone you will find the United States, and parts of Canada, Europe, Asia, and Africa. In the southern temperate zone you will find parts of South America, Africa, and Australia.

Of course it would be very difficult to describe all the plants and animals of these regions. We know that there are forests, great grassy plains, gardens, orchards, and fields of cotton, corn, and wheat in the temperate zones. In fact, much of the food of the world is grown in these regions, because they have a moist, warm growing season and a long harvest season.

The reason for this climate is that this part of the earth never receives the direct rays of the sun. In the

Gendreau

This ranch in Argentina is in the South Temperate Zone. This climate is warm enough and has just enough rain to make it fine grazing land

United States Department of Agriculture, Soil Conservation Service

This farm in the North Temperate Zone has enough heat and rain to raise crops. Why do you think the farmer has plowed his land in this way?

summer, however, the rays are more nearly direct than they are at any other time of the year; therefore this is the warmest season. During the winter everything is just the opposite; yet the winters are warm enough so that we need not suffer. We can live very comfortably in the temperate zones.

There are many different animals in these parts of the world. Some of them live in very wet places, some in forests, some in streams. Others just pass through these regions during their migration.

Look about your school and home and see how many different plants and animals you can find there. Now see how many other kinds of plants and animals living within the temperate regions you can think of. You should be able to think of many kinds.

MAN IN TEMPERATE REGIONS

Man has found the temperate zones the most favorable places on the earth in which to live. He has been able to explore them without much difficulty, since heat and cold have not held him back.

People live in many kinds of groups within these regions. In some places only a few people live on great ranches with hundreds of acres of land about them. Many live on small vegetable farms. Thousands live in villages and cities.

There are not many factories in the warm, moist climates or in the cold climates of the earth. The factories which make clothing, machinery, and many other things

which man needs are usually found in the temperate regions of the earth.

It is not surprising to find all these differences in the way people live in the temperate climates when we think a moment. Vegetables will grow on few of the great ranches, because the rainfall is not enough. So the people who live on ranches make it their business to raise cattle to ship to other places to be used as food and for making clothing.

It would be hard to grow wheat in some places, because the growing season is too short. So the people who live in places that have short growing seasons in the temperate zones do not try to make their living by growing wheat. They work in factories or offices.

So we see that the rain, winds, lakes, rivers, and sunshine have much to do with the way that people live in the temperate climates.

THINGS TO THINK ABOUT

1. Perhaps you can see why man has settled in the temperate regions of the earth.

2. Try to imagine how changed your life would be if climates changed rapidly.

How would the plant and animal life of the earth be affected?

It is a good thing that climates change very, very slowly. We can depend on the climate of any part of the earth to be much the same as it is now all our lives. It takes hundreds of years for the climate of any place on the earth to change.

THINGS TO DO

1. Ask your teacher to help you find some information which shows the population regions of the earth. Where would you expect to find the greatest number of people living?

2. Find a map in your geography book which shows grazing lands, farm lands, and manufacturing centers. Can you connect this information with the information you have about climates?

VII

Weather

WHAT IS THE WEATHER?

THE WEATHER BUREAU

A SCHOOL WEATHER STATION

CLIMATE changes only after many, many years; but weather changes from day to day.

Heat energy from the sun warms the earth. The heating and cooling of the air causes changes in weather. If there were no air around the solid part of the earth to be warmed and cooled we should have no weather, since there would be no wind or rain or snow or sleet or cool days or warm days or very hot days. We should have only a very, very hot day and a very, very cold night.

The air, then, protects us from the great heat of the sun and causes the changing weather that we have.

In the next story you may find the answers to some of your questions about what weather really is and what causes the weather.

What Is the Weather?

WHAT THE WEATHER DOES

Do you think it will be cooler tomorrow?

If it rains, we cannot go to the picnic, can we?

Would it not be fun if we had snow on Christmas?

These are probably some of the questions you have asked at some time or another. They all have something to do with the weather. No one really is able to tell exactly what the weather will be like, but men who study the weather can tell us much about it.

This is very important, since many things which we and other people do every day depend upon the weather. Fishermen need to know if there are going to be bad storms, before they can sail to their fishing waters and back again. Aviators must know something about the weather they will have to go through before they take off on long flights. We need to know whether it is going to rain or not, so that we can take our raincoats to school with us.

No place on the earth has the same kind of weather all the time. A place with a cold climate may have some days which are cooler or warmer than others. If we lived there we should say that the weather had changed. Any place on the earth has the same kind of climate for hundreds of years, but its weather may change from day to day.

The scale at the right of the picture shows how much more air there is over the lower places of the earth

THE AIR AROUND US

All around our earth is a layer of air many miles thick. We know that this air is a mixture of such gases as nitrogen, oxygen, carbon dioxide, and water vapor. There is also dust in the air. The dust may be small bits of dirt from smoke or soil, or fine ashes from volcanoes; or it may be tiny plants which are sometimes too small to be seen.

The water vapor in the air is a gas and cannot be seen. Water evaporates from lakes, oceans, soil, or anything which is wet. Water vapor is very important. Without water vapor there could be no snow, rain, fog, sleet, hail, dew, or frost. Without it there could be no living things on the earth.

All these gases and dust which make up the air weigh something. We do not feel the weight of air upon us, and we do not even notice the air unless the wind is blowing. What the air weighs is called air pressure.

Air pressure is not the same all over the earth. It is less on the tops of high mountains than at sea level. This is because there is less air above the high mountains than there is above a place at the level of the sea. If you were on a mountain two miles high, there would be two miles less of air above you. As an aviator goes higher and higher, he finds that the air pressure becomes less and less because there is less and less air.

You have probably noticed changes in air pressure if you have ever traveled in the mountains. When you went up a mountain, your ears felt queer because the pressure of the air on the inside of your ears was becoming less and less. Then as you went down the mountain, your ears felt queer because the air pressure was increasing.

The heat energy of the sun has much effect on the air. This is because the sun's heat warms the earth. Then the earth gives off heat into the air. The more direct the sun's rays are, the warmer the earth is. So the air above the earth becomes warmer too. In the winter the air may be quite cold at a certain place because the sun's rays are more slanting at that place in winter than at any other time of year. Then the sun's heat is not even enough to melt the snow on the earth. So you would not expect the air to be very warm, would you?

Now this has a great deal to do with air pressure. When air is warmed, it expands, or grows larger. This makes the air weigh less. When air cools, it contracts, or comes together. Cold air weighs more than warm air. Where should you expect the air pressure to be greater —over a cold place or over a warm place?

Then, too, warm air holds more water vapor than cold air. You see proof of this on cold days. The warm air from your lungs has water vapor in it. You can cool this warm air from your lungs by breathing out into cold air or on a piece of cold glass. You know what happens when you do this. If you breathe into cold air you see a small cloud. If you breathe on cold glass you see water vapor on the glass. This is because the moisture in the warm air condenses into little drops of water when it is cooled. Warm air holds more of this water vapor than cold air does.

WHAT IS WIND?

We have just said that warm air expands, or grows larger, when it is heated. This means that it is lighter. When air is cooled, it contracts, or grows smaller. So it grows heavier. As you might guess, this cold, heavy air sinks toward the ground. As it sinks, it pushes the warm, light air aside and up. When this change in air is taking place, we say the wind is blowing.

So wind is caused by the air flowing from a place where the air pressure is greater to a place where the air pressure is less.

United States Weather Bureau

Tornadoes are very destructive winds. Notice the shape of the cloud

If one great mass of air is very warm and another mass of air is very cold, the cold air will rapidly push aside the warm air. The wind will then be strong. If these masses of air are more nearly the same in temperature, the cooler air will move the warmer air more slowly. Then the wind will be gentle.

TORNADOES AND CYCLONES

Sometimes cold air moves the warm air very, very rapidly over a small area, causing a strong twisting wind. Such a wind is called a tornado. Tornadoes can cause much damage. They destroy trees, houses, and anything else in their path.

Cyclones are not the same as tornadoes, although many people call tornadoes cyclones. A cyclone is an area of low-pressure air, very often accompanied by rain and strong winds, though not often causing any damage. A cyclone may be from one hundred to fifteen hundred miles in diameter.

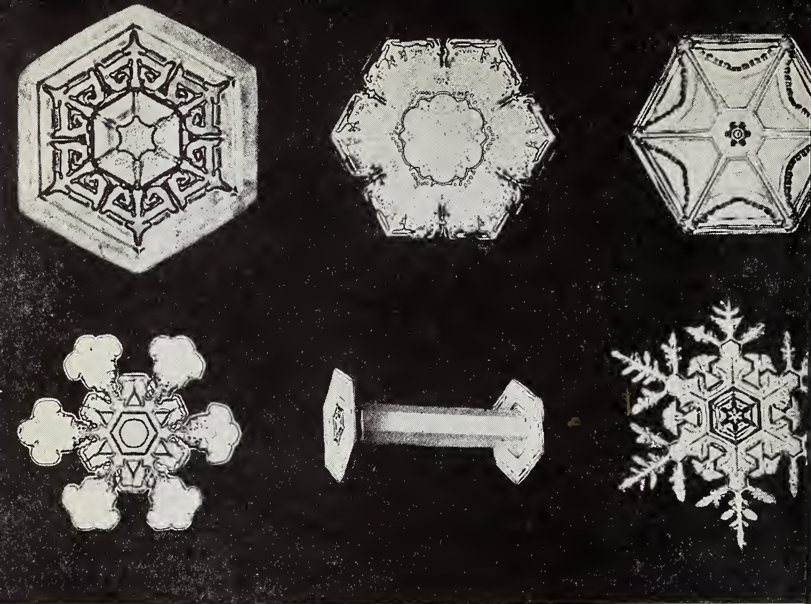
Anticyclones are just the opposite of cyclones. They are high-pressure areas of about the same size as cyclones, usually with clear, dry air and gentle winds.

So cyclones and anticyclones are just ordinary low-pressure and high-pressure areas of the air. We are always in one of these areas.

RAIN, SNOW, SLEET, AND HAIL

These great warm and cool masses of air are all over the earth. We have said that they are always moving, with the cooler air sinking and pushing the warmer air aside and up.

Now when the warm air is pushed up, it becomes cooler and the water vapor in it condenses. We first see this condensed water vapor as clouds, and then it may fall as rain.



No one has ever found two snow crystals which were exactly alike

Snow is not made just as rain is made. When water vapor condenses in air which is below the freezing point, each little drop of water is frozen as it condenses. One tiny crystal is added to another until the snowflake falls. The snow acts as a blanket for the earth. Snow protects plants and soil from sudden freezing and thawing. Rapid freezing and thawing often kills or injures plants.

When the frost leaves the ground during the late winter and early spring, some of the water from the melting snow soaks into the earth. By the time the snow has disappeared, the frost is gone, and grass and other plants are beginning to grow.

Water may fall to the earth in still another way. It may fall as sleet. Sleet may be raindrops which have been frozen or snowflakes partly melted and frozen again. Sleet forms when raindrops or snowflakes fall through layers of warm and then very cold air near the earth.

Hail is not like sleet. It usually hails only in spring and summer during very hot weather. After water vapor has condensed into raindrops, these are carried swiftly upward by currents of warm air into places of icy air. There the drops of water are quickly mixed with snowflakes and frozen. This makes a cloudy layer of ice. In this way little hailstones are formed.

tice the layers of ice in the hailstones which have been cut open. Do you know why this happens?

United States Weather Bureau

A hailstone may fall until it reaches another current of warm air. Here it gathers some moisture and is rushed up to icy air again. The hailstone may be tossed up and down in this way many times. Break open a hailstone, if it hails in your neighborhood, and notice the layers of cloudy ice and clear ice.

Some of the water which falls to the earth as rain, snow, sleet, or hail returns to the air by evaporation. The water that evaporates at one place may fall with other moisture on some other part of the earth many, many miles away.

WHAT IS DEW AND FROST?

Most of us have seen dew even if we have not seen hail, sleet, or snow. When we walk through wet grass in the early evening, our shoes become damp. Dew does not fall on the grass. It is formed just where it is found. At night the earth becomes cooler than the air. Dew is formed on anything when that object is cooler than the air around it. This is because the water vapor in the warm air condenses when the air touches something cool. The same thing happens to a glass of ice water on a hot, moist summer day.

Grass cools more quickly than a rock. So, in the early evening, dew is formed on the grass before it is formed on a rock.

Frost is formed much as dew is formed. We find frost in places where dew is found, but it is formed when the temperature is at or below the freezing point

of water. As the water vapor in the air condenses, tiny crystals of ice are formed because of the cold, instead of drops of water. Then we have frost instead of dew.

THUNDERSTORMS

Thunderstorms come most often in the summer. We may expect one when it is very hot, when the air is quiet and there is much water vapor in the air. The very hot air from the earth's surface is pushed up quickly by a cool mass of air. As the hot air is pushed up, it cools. Then the water vapor condenses and masses

Dew evaporates very quickly after the sun begins to shine

Lynwood Chace

of dark clouds appear. Rain and hail may fall from these clouds.

A thunderstorm cloud is often called a thunderhead. It is a large, dark cloud shaped something like an anvil. Such clouds almost always come from the west or southwest.

As these very dark clouds come near, we see lightning and hear thunder. Very soon heavy rain begins to fall. Before long, the storm passes on toward the east. Sometimes a gentle rain begins to fall then, and sometimes there is little rain after the storm has passed.

The lightning is probably caused in this way. Electricity is always present in the air. Every tiny bit of dust or water in the air carries a very small amount of electricity called a charge. Raindrops have two kinds of charges. The very small raindrops which are carried upward in a thundercloud have a negative charge of electricity. The larger raindrops at the bottom of the cloud have positive charges of electricity. When very great amounts of these two charges get near each other there is a flash of lightning.

A flash of lightning may take place from one part of a cloud to another, or it may take place between one cloud and another cloud. Since the earth may also have a charge of electricity, lightning may take place between a cloud and the earth.

You see this happen when a "streak" or "zigzag" lightning strikes a tree or building or other object on the earth. When you see "sheet" lightning, that is, a flash of lightning that does not zigzag, you know the

© R. H. Robins

Lightning is a huge electric spark. Do you know what to do if you are out of doors in a thunderstorm?

thunderstorm is so far away that you cannot see the zigzag lightning. You see only its reflection in the sky.

Thunder is caused by lightning. Lightning makes the air about it very hot. It is believed that this causes the air to expand so suddenly that the expansion is almost like an explosion. The sound which this sudden expansion of air makes is called thunder.

No one is ever hurt by thunder, and few people are ever hurt by lightning. But it is wise to know a few things about where to go during a bad thunderstorm. A very safe place to be is in a large modern building. This is because any lightning which might strike the building would travel through the steel part of the building into the ground.

If you are caught outdoors, you should not stand under trees, because they make good paths by which lightning can pass into the moist earth.

THINGS TO THINK ABOUT

1. Why does smoke rise?

2. If you have ever lived near a lake or near the ocean, you know that there is usually a breeze from the water in the morning. In the evening the breeze is often from the land to the water. Can you tell why this happens?

3. Does a change in the weather make you feel different? Do you suppose other animals feel weather changes as much as you do?

4. How does weather affect plants? You have to water your garden more on hot summer days than on cool ones. In what other ways does weather affect plants?

THINGS TO DO

1. Drop a thin piece of paper over a hot radiator. Does the warm air make the paper go up?

2. Here is a way to make "rain." Heat some water in a pan until it boils. Now hold a cold plate about three feet above the pan. Where do the drops of water on the plate come from? Can you see the water leaving the pan?

This same thing will happen in your aquarium if you put a glass top on it.

The Weather Bureau

GOVERNMENT WEATHER STATIONS

There are men all over the world who watch the weather carefully. The places where the weather is watched are called weather stations. These weather stations may be on the tops of mountains where men watch the weather even during the coldest months of the year when snow is deep. Some weather stations are in the big cities on the tops of tall buildings. Others are in the valleys or in the very dry parts of the world.

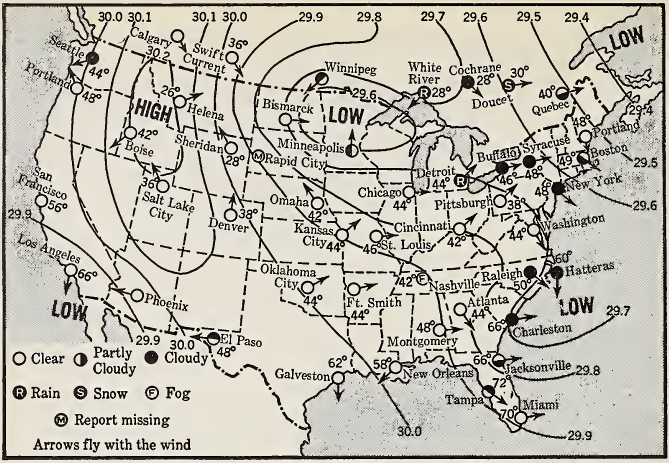
At these stations several things about the weather are recorded. Here are some of them:

The direction and speed of the wind
The air pressure at different times during the day
The temperature at different times during the day
The amount of moisture in the air
The amount of rain, if any, that falls during the day
The hours of sunshine
The kinds of clouds

When a record has been made, it is immediately sent by telegraph to a larger station. Then a report is sent on by telegraph to the United States Weather Bureau at Washington, D. C. In Canada the central weather bureau is located in Toronto, Ontario. The Washington Bureau and the Toronto Bureau also exchange weather reports.

As the reports come in from smaller stations scattered all over the country, they are recorded on a large

This map shows the most important weather stations in North America. Why is it important to have so many weather stations?



How could you tell from this map that Minneapolis will probably have cooler, clear weather in a day or two?

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map. This map gives information about

Temperature
Air pressure
Amount of moisture in the air, or humidity
Amount of rain, snow, or sleet in 24 hours
Speed and direction of the wind

Look at a weather map and see if you can find all these things recorded on it.

The high-pressure and low-pressure areas move across the country from the west to the east. If you will watch the weather maps for several days, you will see that this is true. Weather forecasters know that the high-pressure and low-pressure areas move in these

ways; so they try to estimate the speed at which the air is moving. Then they know about when to expect a high-pressure or a low-pressure area to arrive.

Of course they know that a low-pressure area is usually one of cloudy, often rainy, and warmer weather, and that a high-pressure area is usually one of clear, sunny, and cooler weather.

Weather forecasters are not always able to tell exactly what the weather will be; but many years of practice make them very expert in forecasting the weather.

USE OF THE WEATHER BUREAU

The weather bureau is of use to so many different people that it would be impossible to mention them all.

You know that aviators must know about the weather before they begin a flight. This is just as true for short flights as it is for long-distance flights.

When you are planning an automobile trip during your vacation, you are most likely interested in what the weather will be on the day of your trip.

Even the bakers, especially in large cities, are interested in what the weather will be. On warm, summer days many people go into the country or parks for picnics. This means that they will need sandwiches. The bakers need to know if the day will be warm so that they can bake an extra supply of bread.

The weather bureau warns of floods, high winds, frosts, and other weather that might cause damage. All of us depend on weather forecasts a great deal.

Gendreau

This man at an airport weather station is making a weather map from reports that come to him from all over North America

A School Weather Station

You may be interested in observing the weather and in keeping a record of weather changes. Of course you will not be able to forecast the weather accurately; but you may find that you are able at least to read the weather maps in your newspaper more accurately.

A thermometer is quite necessary for your weather station. It should be outdoors. It might be put just outside your window; but the best place for it is out on the school ground where air coming from any direction can touch it. There should also be a top over the thermometer to protect it from the sun's rays.

Air pressure must be measured with a barometer. Some barometers have mercury in them; others do not. But all barometers work because of air pressure. The kind that is most often used in our homes is the aneroid barometer.

The aneroid barometer has a little metal box inside which has almost no air in it. When air pressure around the box is increasing, it pushes the sides of the box together a little. Then the needle of the barometer moves to the right. We say the barometer is rising. When air does not press so much on this box, the sides move out, and the needle goes to the left. Then we say the barometer is falling.

It is not necessary to keep your barometer outside. Air pressure is almost the same inside the room as outside. There are so many little air spaces around the windows and under the doors of your room that air

pressure changes inside as well as outside. The barometer records themselves are not so important; but the changes in the air pressure from day to day and sometimes from hour to hour are important. An accurate barometer is hard to make, but you can get barometer readings from the newspaper.

Rainfall may be measured with a rain gauge which you can make. You will need a can, such as a coffee can. It should have a flat bottom and straight sides. The can should be fastened to a board and put in a level open place. The amount of rainfall can be measured with a ruler.

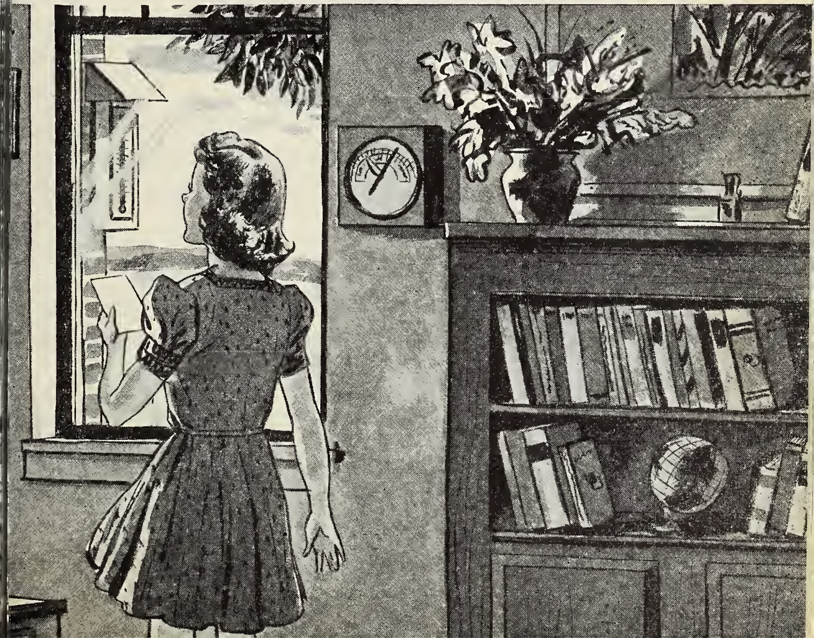
This schoolroom has its own weather station. Notice the barometer on th
school grounds. The trees help to tell how hard the wind is blowin

Along with a record of the rainfall you should probably make a record of whether the sky is very cloudy, cloudy, or clear.

It is easy to tell the direction of the wind by watching a flag on top of a tall building or on a pole in an open space. If you live in a large city with many tall buildings, it is hard to tell the real direction of the wind.

Some children keep a record of the daily temperature and air pressure on charts like those in this picture. Other children make a large calendar. In each space they put the temperature, the air pressure, the amount of rainfall or snowfall, and the direction and speed of the wind.

all. The thermometer is outside. A rain gauge and wind vane are on the
he boys and girls have made temperature and air-pressure charts



Here is a table which may help you in judging the speed of the wind. This table is adapted from a wind scale made by a scientist named Beaufort.

Calm

Leaves on trees are still
No wind blowing

Gentle wind

Leaves just move
Speed about 10 miles an hour

Moderate wind

Branches of trees move; dust blows
Speed about 20 miles an hour

Strong wind

Trees blow back and forth; it is hard to walk
Speed about 35 miles an hour

Storm

Tree branches are broken; wind does much damage
Speed from 45 to 100 miles an hour

If you keep a weather record from day to day, you will begin to notice certain relationships between temperature, the direction and speed of the wind, and the air pressure.

Make a weather forecast for the next day when the temperature is falling and the barometer is rising. Check your forecasts with a daily weather map to see how nearly right you are.

THINGS TO THINK ABOUT

1. Scientists who are interested in the weather are always working on ways of forecasting weather more accurately. Aviators make flights several miles high to make air-pressure and temperature records. They do this because it is thought that any air changes high in the air may have a great deal to do with air changes nearer the ground. Watch your newspapers for more about this. Man is learning more and more about the weather.

2. How has radio helped in forecasting weather?

3. Weather bureaus are found not only in North America but all over the world. Weather forecasts are sent from one country to another every day. Why do you suppose this is done?

VIII

What Are Magnetism and Electricity?

MAGNETS AND COMPASSES

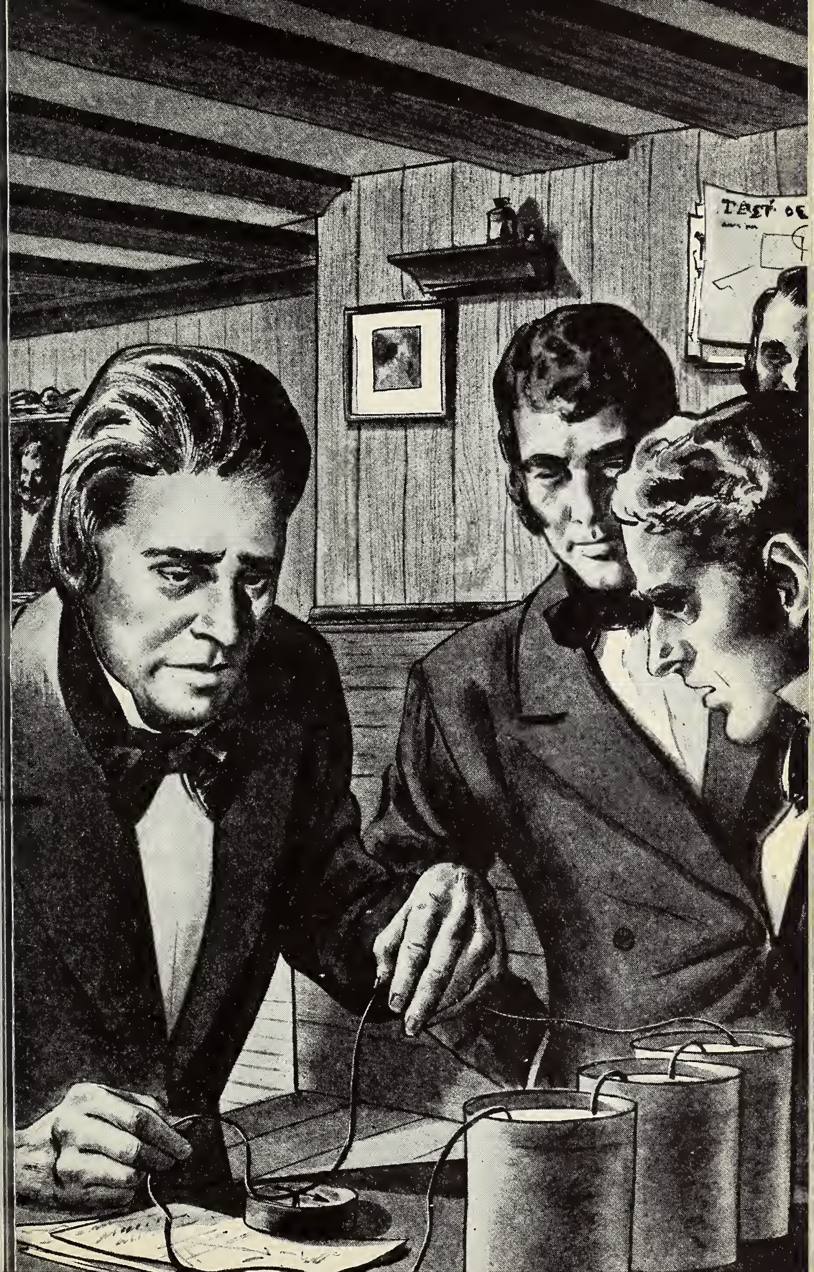
ELECTROMAGNETS

ELECTRIC CIRCUITS

WHY DO ELECTRONS MOVE?

ELECTRICITY CAUSED BY FRICTION

ALL ELECTRICITY IS REALLY THE SAME



THE HEAT and light energy of the sun have much effect on the earth, especially on weather and climate.

It is possible to trace all the energy which we use back to the sun, if we believe that the earth itself came from the sun.

We use several different kinds of energy. A few kinds that we use are heat energy, light energy, moving energy, and electrical energy.

In the next story you will find more about this last kind of energy, electrical energy. You will find out about some ways in which it is made. You will see that it can be changed to other kinds of energy.

Sometimes great scientific facts are discovered by accident. On page 226 there is a story about the scientist who is shown in the picture on page 209. This Danish scientist, Oersted, made a discovery which was used as a starting point for much work with electricity and magnetism.

No one can make electrical energy, but everyone can and should be able to use it.

Magnets and Compasses

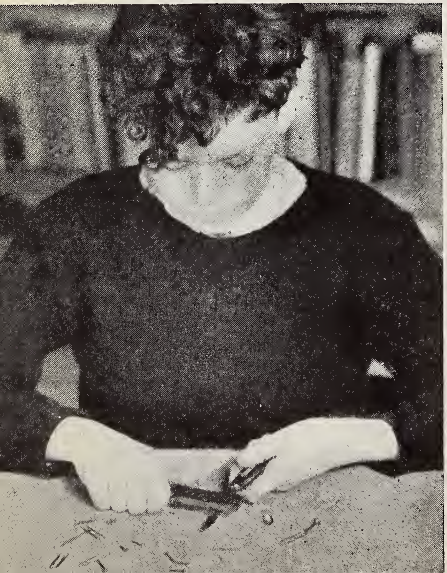
WHAT MAKES A MAGNET WORK?

We do not know just when or how natural magnets were discovered. Neither do we know for certain how they received the name *magnets*. Perhaps these magnetic stones were first found, in ancient times, by people living in Magnesia, a district of Greece; so the word *magnet* may have come from the name Magnesia.

The Chinese knew about magnetic rocks, or loadstones, and used them for compasses hundreds of years ago. The old records of the Hebrews and the Romans show that loadstones were used by them too.

Your knife blade will be a better magnet if you stroke it in the same direction each time

Richie



About three hundred years ago an English scientist named Gilbert made the first important experiments with artificial, or man-made, magnets and natural magnets. Since then men have not thought of magnets as trick objects. They have experimented with them more and more in order to make them more useful. Even today we are still experimenting with magnets.

It is not hard to make a magnet. A knife blade may be magnetized in the following way: Just stroke the knife blade with a magnet several times. The knife blade may be tested for magnetism by trying to pick up small nails and tacks with it.

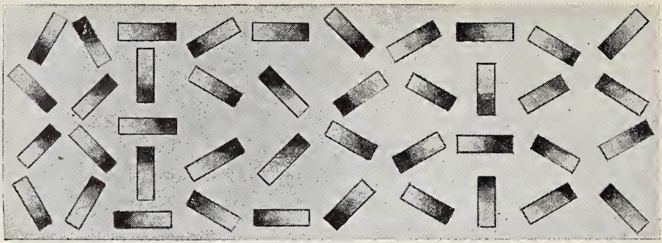
Richie

Each of these four nails was a magnet for a little while after it dropped off. Do you know which was the strongest?

Iron and steel are "magnetic substances" because they can be attracted by a magnet. Many substances are not attracted by magnets. These cannot be made into magnets. Try picking up wood, rubber bands, cloth, or brass with a magnet. Will they cling to the magnet? They cannot become magnetized by the magnet.

This is a good thing, for our world might be quite different if all things were good magnetic substances. What a hard time we should have trying to keep objects separated! If cloth were magnetic, it would be very difficult to make a bed. If our shoes were attracted by the sidewalk, walking would be quite a problem. What a queer world it would be!

If your magnet is strong enough, you may make a "string" of small nails. Put one nail on the end of the



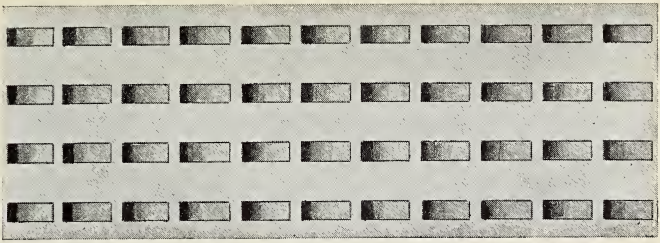
Molecules may be arranged this way in an unmagnetized piece of steel

magnet. Then hang as many nails as you can on this first nail. In the picture on page 213 you can see that four nails have been placed on a magnet in this way. When you hold the top nail and remove the magnet carefully, the entire string will stay together for a few moments. Each of the nails was a magnet for a few moments. They "borrowed" some magnetism from the magnet for a while.

Pieces of soft iron, such as nails or tacks, sometimes become magnets if they are left close to a strong magnet. They too borrow magnetism.

So these are two ways by which we can make magnets: A piece of soft iron can be rubbed with a magnet until it becomes magnetized. Nails or tacks which remain near a magnet for a long time will also become magnetized.

Look at an ordinary needle and one which you have magnetized. They do not look different; yet we know that they are very different. Scientists are not sure about what happens to a needle when it is magnetized.



Molecules may be arranged this way in a magnetized piece of steel

Here is an explanation that some scientists have given us. We do not really know if it is true.

All objects are made up of tiny particles. They are very, very small—so small that you cannot see them. These tiny particles are called molecules. Each molecule of steel or iron is a little magnet, with a north and a south end, or pole. These magnets are so tiny that they cannot be seen even with a microscope.

If steel and iron contain little magnets, you would think that all pieces of steel and iron would act as magnets. This is not true. If a bar of steel or iron is a magnet, the molecules are arranged in a certain way.

Stroking the knife blade with a magnet makes the little particles inside the blade rearrange themselves. These molecules are all in disorder at first. As the magnet passes over them, their positions change so that their north poles all point in the same direction and their south poles all point in the opposite direction. The blade is now magnetized. If anything disturbs this arrangement of the molecules, we have only an ordinary unmagnetized piece of iron or steel left.

Perhaps some day we shall have a better explanation of just what magnetism is.

We have said that a magnet has poles. Each of these poles will attract and repel. Do you know how to find the number of poles any magnet has?

Magnetize a steel knitting needle by stroking it with one end of a fairly strong magnet. Be sure to stroke the needle in the same direction each time. Test your needle to see if it will pick up iron filings, which are small pieces of iron that you may get from a machine shop. If the needle picks up the filings, it has become a magnet.

The south pole of one magnet is pushing the south pole of the other magne away. What will happen when the north pole comes near the south pole

Richie

We must now test it to see which is the north pole and which is the south pole. A compass can be used for this test.

Hold one end of your magnetized needle close to the north pole of a compass needle. You know, of course, that the north pole of a compass needle points toward the north. If the compass needle remains still, the south pole of the needle is next to the north pole of the compass. Poles which are not alike attract each other. Hold the other end of the needle to the north pole of the compass. Does the compass needle turn away as it should? If it does, you have found the north pole of the knitting needle. You may dip the north pole of the magnetized needle in a bit of red paint, so that you will always be able to tell which is the north pole.

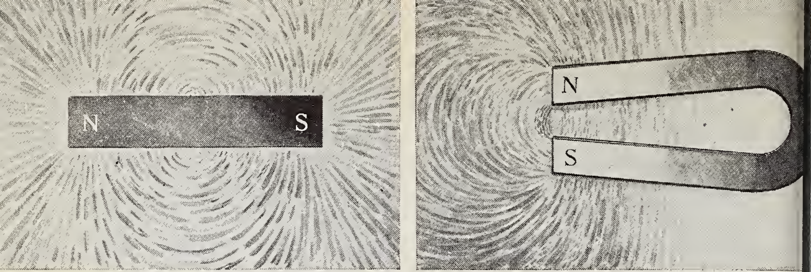
Can you find any other poles on the knitting needle?

Perhaps your teacher will help you cut your knitting needle in half. How many poles does each half have? Remember that each half is now a complete magnet.

MAGNETISM IS A STRONG FORCE

Farmers turn their cattle out to pasture. They usually put them into fields which are set off from the rest of the farm by fences. The cattle can go anywhere within the fields to eat; but they cannot go beyond the edges of the fields because of the fences.

Magnets have fields, too. These fields have no fences around them as the cow pastures have, but they are fields just the same. The field of a magnet surrounds



The lines show how iron filings would be arranged in the magnetic field of a magne

the magnet. It is the space about the magnet within which iron and steel are attracted to the magnet. We call it the magnetic field.

A very strong magnet has a larger magnetic field than a weak magnet. It can attract objects farther away from it. The objects that a magnet attracts are always in the magnetic field of that magnet.

Let us see if we can find the size of the magnetic field of a magnet. Lay a magnet on the table. Place a piece of cardboard or a piece of glass over it. Now sprinkle small tacks or iron filings on top of the cardboard or glass. Tap the cardboard or glass gently. The tacks or iron filings will arrange themselves in lines on the cardboard or glass. These lines are crowded together near the poles of the magnet. Do you see that some of the tacks are outside the magnetic field of the poles? They are too far away to be attracted by the magnet. It has not power enough to pull them into its field.

The field of the magnet does not go out in just two directions from the magnet. A magnetic field is all around a magnet.

Magnetism is strong. It attracts iron filings even if there is paper between the magnet and the filings. Is magnetism strong enough to act in water? Place tacks in the bottom of a pan of water. Put the magnet in the water and see if the tacks are attracted toward it. Wipe the magnet off carefully when you have finished. Magnets will rust just as other pieces of iron and steel will.

Magnetism will also pass through other substances. Try flat pieces of glass, zinc, copper, and tin in the following manner: Put a pile of tacks on the table. Hold a piece of glass between the tacks and the magnet. Do the tacks cling to the glass as if they were trying to come through it to the magnet? Now hold a piece of zinc, then copper, and lastly tin as you did the glass.

Was your experiment with the "tin" successful? Remember that a tin can is really iron with a thin covering of real tin. A piece of a tin can will be attracted by a magnet because it is made mostly of iron and not tin. Pieces of metal which can be magnetized will not allow magnetism to pass through them.

Scientists do not know why this is true. They do know that magnetic force will pass through cloth, thin wood, paper, glass, copper, aluminum, brass, and most of the other metals. They think that the magnetic force is used up in magnetizing an iron plate rather than passing through the plate and attracting the nails.

Even though we cannot see magnetism and cannot be sure of what happens in a magnet, we are able to use magnetic force in many, many ways.

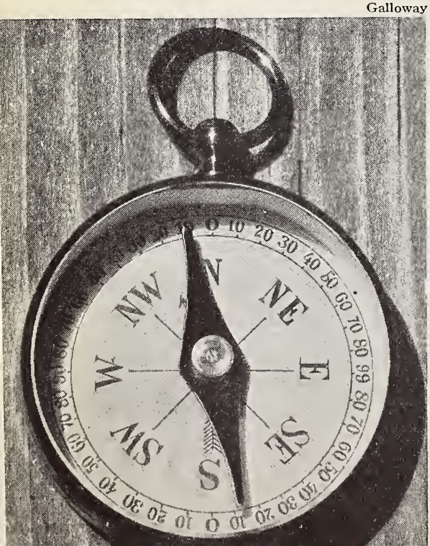
COMPASSES USE MAGNETS

Perhaps you never thought that a compass uses a magnet, but it does. There is a needle that points north and south in a compass. It is a small bar magnet which can turn around. The glass is used only as a protection for the needle inside. Could you explain why the glass does not affect the magnetic needle?

The Chinese are supposed to have discovered that magnets could be used for compasses. However, the Arabs, the Greeks, the Finns, and the Italians are also said to have been the discoverers. No one knows who did make the discovery.

During the thirteenth century compasses were used to guide the ships on the Mediterranean Sea. Goods were carried from the east to the west, and sailors found compasses very useful. Long voyages were not often attempted before the compass was invented. The compass aided Columbus in his voyages of discovery.

Compasses are of great value to sailors today. Compasses help them to



The needle of a pocket compass points north and south

Galloway

go in the right direction. Sometimes a compass is affected by the iron and steel in a ship. Seamen are very careful to protect their compasses from other magnetic substances. Do you know why this is true?

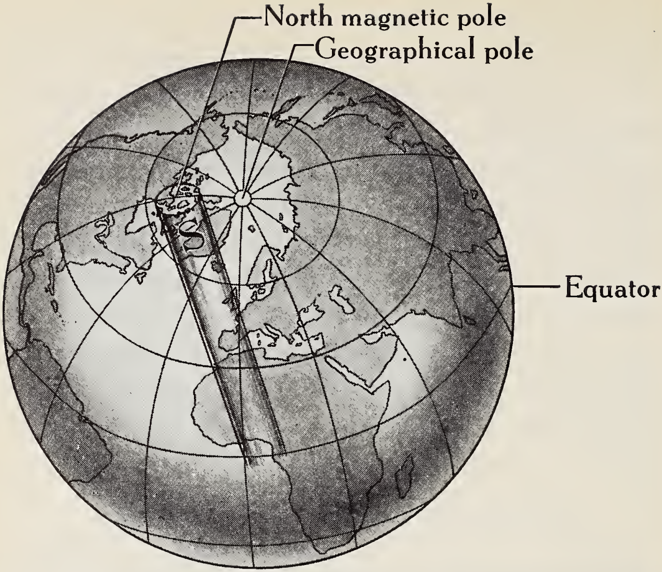
A compass can be made with a bar magnet and a piece of string. Use a bar magnet with the poles marked on it. Hang the bar magnet by a string so that it will swing around in the air. It should point north and south when it comes to rest. You could use a knitting needle which you have magnetized instead of the bar magnet. The north pole of the needle may be marked with red paint.

THE EARTH IS A HUGE MAGNET

The reason why compasses point north and south is that the earth itself is a huge magnet. It has a north magnetic pole and a south magnetic pole. These magnetic poles are different from the north and south poles you know about. The north magnetic pole is near Hudson Bay, about twelve hundred miles from the true north pole. The true poles you read of in your geography are also called geographical poles. Look on the globe and find these poles.

The earth is a very large magnet. It is so strong that its magnetic field reaches over the whole earth. Even when a compass is several thousand miles from the poles, the needle will point to them.

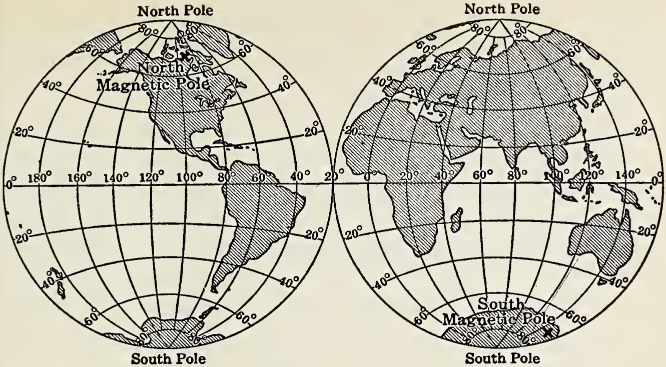
Because magnetic poles do attract each other, we can use a compass to tell direction.



If we imagine a large magnet inside the earth, one pole would be near Hudson Bay. Where would the other pole be located?

Sir James Clark Ross discovered the north magnetic pole in 1831. The south magnetic pole is in the antarctic. It was discovered by Sir Ernest Henry Shackleton during his explorations in 1907 to 1909. The explorers found the magnetic poles with compasses.

On most places of the earth a compass does not point to the true, or geographical, north. It points toward the north magnetic pole. If the compass pointed true north, it would point in the direction of the North, or Pole, Star. This star is almost directly over the true, or geographical, north pole. You probably have read of ships



This map shows the location of the magnetic and geographical poles of the earth. Do you know why it is so important for sailors and aviators to know there are two north poles?

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sailing *due* north or *due* south. This means that they are sailing toward the true north or the true south pole.

When compasses were first used, people knew that the compass needle always pointed in a northerly direction; but they noticed that it did not always point to the true north. This they could not understand, because they knew nothing of the earth's magnetic poles. We are told that the sailors who made the voyage with Columbus were worried because the compass did not point due north. Columbus explained to them that the changing of the North Star was the cause of this. Of course we know now that this was not true. We know that the magnetic north pole is one cause for the difference between the true north and the direction the compass points. This difference has been found out for all

places on the earth. So ship captains know at any place where the true north is if they know just where the magnetic north pole is located.

Scientists do not know exactly why the earth is a magnet. Perhaps the best theory is the one which explains that the earth is magnetic because it rotates, or spins on its axis. The rapid rotation of the earth has caused the molecules within the earth to be disturbed.

We have reason to believe that the sun is surrounded by a magnetic field. The earth, of course, is within the sun's magnetic field. The magnetic effect of the sun may have caused the molecules in the center of the earth to line up in one direction. This would cause the earth to have poles. No one is sure about this explanation of the earth's magnetism, but it seems to agree with many things we know about magnetism.

But we can be sure of this: the earth has two magnetic poles, and a compass needle points toward the north magnetic pole.

THINGS TO THINK ABOUT

1. Aviators once had to depend on compasses almost entirely to help them find their way after dark. Why do they not have to depend only on compasses now?

2. When Admiral Byrd flew over the north pole he could not use a compass to find his way. He found his direction from the sun. Why did he have to do that?

3. Do you suppose the scientists will always use the theories which you have read about to explain how magnets work?

THINGS TO DO

What do you suppose would happen to the poles of a magnet if you could break it into two parts? Would there be a north pole on one piece and a south pole on the other?

Some small horseshoe magnets, such as the ones you might buy as toys at the ten-cent store, are easily broken. Break one of these. Does one piece have a north pole and one piece have a south pole, or does each piece have a north and a south pole?

Why is this?

Electromagnets

ELECTRICITY AND MAGNETISM

You have read about two kinds of magnets. One kind is the artificial, or man-made, magnet. The other kind is the natural magnet which we find scattered about the earth.

There is another kind of artificial magnet, which does many things for us. It makes our doorbells ring. It helps us to talk over the telephone and to send telegrams. It also makes the radio possible.

One day, a little more than a hundred years ago, a scientist named Oersted was working in his laboratory in Denmark. He was performing some experiments with electricity. A compass was brought near the electric current. When this was done, Oersted noticed a very strange thing. He saw the needle of the compass move. He became so interested in the compass needle that he stopped the experiment he was working upon. He began to watch the compass. The needle of the compass moved every time it was brought near the wire through which an electric current was flowing. This showed Oersted that an electric current affected the compass. He was the first to discover that a wire carrying an electric current acts like a magnet.

You can prove Oersted's experiment for yourself. Use a dry cell to furnish the electricity. Connect one end of a piece of bell wire to one pole of the dry cell. Place a compass on the table, and let the needle come

to rest in its north and south position. Hold the wire above the compass so that the wire is parallel with the compass needle. Now connect the other end of the wire to the other pole of the dry cell. Does the electricity seem to affect the compass? You remember that a magnet would make the compass needle move. The electric current seems to act like a magnet because it makes the compass needle move.

What would happen to the nails on the magnet if the circuit were not complete?

Richie

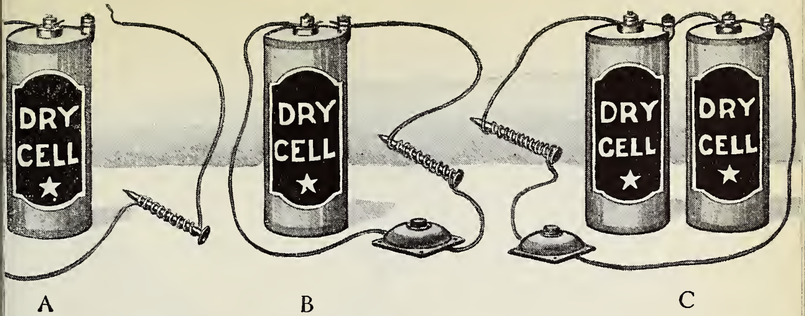
When this important discovery was put to use, the first real electromagnet was made. It is called an electromagnet because it is a magnet which is made by the use of electricity.

DOES AN ELECTROMAGNET HAVE POLES?

To make an electromagnet you will need a dry cell, some bell wire, and a piece of iron, such as a large nail. Wind the wire carefully around the nail. Fasten the ends of the wire to the dry cell. Be sure to remove the insulation, or covering, from the ends of the bell wire before connecting them to the posts of the dry cell. To do this, scrape each end carefully. Now dip the end of the nail into some tacks, pins, or needles. Does the electromagnet pick up the same things that other magnets will pick up?

The electromagnet is very useful, because it can be turned off and on. Break the circuit by disconnecting one of the wires from the dry cell. The electromagnet no longer attracts the tacks. The nail may attract one or two tacks for a few moments, but it will soon lose its magnetism. You now have only an ordinary piece of iron and some wire, but no magnet.

We have not yet used the compass to see whether our electromagnet has poles. Test the electromagnet with the compass. You can see that an electromagnet is just like any other man-made magnet in that it has two poles. Find which end is the north pole and which is the south pole.



How would you make the electromagnets in A and B work?
Why is C a better electromagnet than B?

Now disconnect the wires from the dry cell. Turn the cell around so that the wire which was connected to the middle pole is now connected to the outside pole. Do you remember which end of the electromagnet was the south pole? Hold that same end to the north pole of the compass needle. Since the needle turns away, we know that the pole of the magnet which was a south-seeking pole is now a north-seeking pole. When we changed the connections on the dry cell, we changed the poles of the magnet. We can change the poles of the magnet by making the electricity flow first one way and then the other.

ELECTROMAGNETS HAVE MANY USES

The strength of an electromagnet can be changed by changing the current. If the electric current is made stronger, the electromagnet will be stronger. Try making a stronger magnet by adding another cell.

Galloway

Do you see the wires which carry the electricity to this powerful electromagnet?

Huge electromagnets are used where heavy lifting is necessary. Great pieces of steel or iron can be moved by the use of electromagnets. The stronger the current, the more the electromagnet can lift.

A soft iron core is used in all electromagnets. Soft iron does not keep its magnetism as steel does. This can be explained somewhat as follows. The molecules in the soft iron are not packed very closely together. Therefore the molecules seem to go back to their original positions even after they have been magnetized. However, this is not true of steel. The molecules of steel are packed closely together. They stay in their magnetized positions after they have once become magnetized. You can make a permanent magnet from the core of an electromagnet, if you use a piece of steel for the core rather than a piece of soft iron.

The uses of the electromagnet are many. Making permanent magnets and using lifting magnets are only two of these many uses. Did you know that electromagnets may be found in radios, telegraphs, telephones, buzzers, and doorbells?

THINGS TO DO

1. If you can get an old telephone receiver take it apart to find the electromagnet.

2. Find directions for building a telegraph set and build one.

Electric Circuits

MAKING AN ELECTRIC CIRCUIT

Suppose we examine a doorbell circuit to see how it works. The things we shall need if we wish to make a doorbell circuit are a doorbell, bell wire, and a dry cell. Connect the dry cell and doorbell together just as you connected the electromagnet. Perhaps the picture will help you to connect the wires properly.

Do you notice that there is no way of stopping the bell from ringing unless you disconnect a wire? This is because you have made a *complete* circuit.

Through this complete circuit flows a current of electricity. An electric current is a flow of electrons. But what are electrons? Let us see if we can get some idea of what they are. We have said that all things are made of molecules. A molecule of any substance is made of a certain number of atoms. Atoms are very, very small. Yet scientists have discovered that these very, very small atoms are themselves made of protons and electrons. It is the protons and electrons which give us the electrical effects that we know. Protons are positive (+) charges of electricity. Electrons are negative (–) charges of electricity. These are names which scientists gave electricity so that they could describe what happened when they were working with electricity.

Electrons can be disturbed so that they move about. However, they will not flow unless we make a kind of circle, or complete path, through which they may travel.

Richie

All connections in an electric circuit must be checked carefully

This path may contain wires, electric-light globes, dry cells, bells, and other things. When these are all connected together, one after another, a path is made in which the electrons may travel.

The electrons do not move of their own accord. They need a "pusher." Dry cells furnish the electrical push, or *pressure*, to move the electrons. But before the electrons can begin moving, they must have some way to return to the dry cell. That is the reason why the circuit must be complete, or entirely connected.

Disconnecting the wire from the dry cell will stop the movement of electrons. This is because it is very difficult and usually impossible for the electrons to move through an air space. Do you wish to stop the bell from ringing in an easier way? Then you may use a switch or a push button in your circuit. When you pull up the key of the switch, an air space is made through which the current cannot flow. When you push the key down,

the circuit is immediately completed. Electricity begins to flow again. The same thing happens when you press the push button.

CONDUCTORS AND INSULATORS

Look at a piece of bell wire. You will see that it is made of copper wound with cotton. Copper conducts, or carries, electricity through it. Those materials which will allow electricity to pass through them easily are called conductors.

Copper is perhaps the most useful of all conductors. But some of the other metals, such as gold and silver, are even better conductors. Do you know why we use copper wire rather than gold and silver wire?

Our bodies are also very good conductors. That is why we must be careful not to touch the inside of electric-light sockets. Our bodies make a natural circuit through which the electrons may flow. The amount of electricity running through a house circuit is enough to give us quite a shock. Sometimes it proves to be dangerous.

Electrons will not move through the air very easily, because dry air is a poor conductor of electricity. There are many substances which are poor conductors of electricity. Some of these are glass, dry cloth, wood, and hard rubber. When these poor conductors are used to prevent the escape of electricity, they are called insulators. Bell wire is insulated with cotton and rubber so that the electricity will not escape from the wire.

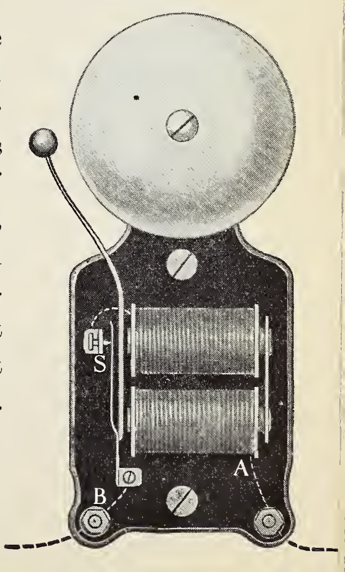
TRACING THE PATH OF ELECTRONS

We have been careful to make a complete circuit with a dry cell, a bell, and a switch properly connected with insulated bell wire. The electrons pass from the dry cell, through the wire to the switch, then to the bell, and back to the dry cell. Can you trace this circuit?

Here is an experiment which is a bit harder. Can you trace the path of the electrons through the bell? Perhaps the picture on this page will help you. You will find the examination of the bell itself even more helpful.

Let us start at *A* in the picture. The electrons pass through the coils of wire so that they make an electromagnet. Since an electromagnet will attract iron or steel, the hammer of the bell is pulled over toward the magnet. This, of course, causes the hammer to strike the bell, and we hear a sound.

The poles of the electromagnet are near the hammer



Now perhaps you notice that the hammer moves away from the bell. It seems that the magnet is no longer able to attract the hammer. This is exactly true. Do you see why? If you will look at the place marked *S*, you will see a sort of switch. When the hammer is touching *S*, the electrons can flow through the lower part of the hammer. Then they go out through *B* and back to the battery. This makes a complete circuit.

But when there is a complete circuit we have a strong electromagnet. This pulls the hammer over again. For a moment there is no complete circuit. The electromagnet no longer works. So the little screw *S* acts as a switch. First it makes the circuit complete, and then it breaks the circuit. In this way we have a continuous movement of the hammer and a continuous ringing of the bell.

The same use of the electromagnet is made in radio loud-speakers, telephone receivers, and telegraph receivers. Perhaps you can examine some of these in order to see just where the electromagnet is located and how it works.

If a bell or a light in a circuit does not work as it should, the circuit is probably not complete. It would be best to go over each part of the circuit to see that it is in order.

Did you make all the connections tight? Test each screw to make sure that nothing is loose. If all the connections are made properly and the bell still does not ring, what else might be wrong?

Are you sure the dry cells are strong? If you are not sure, test each one in the following way: Fasten a small socket and globe from some Christmas-tree lights to the dry cell. If the globe does not light, the cell is probably dead.

Sometimes the bell or the buzzer may be damaged. If you cannot find anything wrong with the bell, ask your teacher to help you.

In any case, your bell would not ring because there

was not a complete circuit. One or more of the following things may have happened: The wires were connected improperly. Electricity could not flow through the dead cell. Electricity could not flow through the bell because it was damaged. Before electricity can flow, there must be a complete circuit.

THINGS TO THINK ABOUT

1. What is a short circuit? Does it seem reasonable to think that an electric current always travels in the shortest path?

2. Remember that your body is a good conductor of electricity, especially when it is wet. Never turn on an electric light while you are standing in the bathtub. Can you explain why doing such a thing is very dangerous?

THINGS TO DO

Try to trace the path of the electric current through a circuit with a buzzer in it.

Can you find out why the buzzer makes the sound it does? Remember that a buzzer is much like an electric bell.

Why Do Electrons Move?

WHAT IS INSIDE A DRY CELL?

Electric currents do not begin to flow of their own accord. There must be some place where they begin. A force must start their movement in a conductor. This force is called electrical "push" or pressure.

Think of some of the circuits you have made. You may discover what furnished the electrons and the electrical pressure that made the electrons move. Electrons are set free in the dry cell. They are then pushed out into the wires of the circuit. They travel around the circuit and back to the dry cell.

Perhaps it would be a good thing to open a dry cell to see if you can really see any electricity. The necessary tools for this experiment are a chisel and a hammer. Split the dry cell apart down the side and at the top and bottom.

There is a paper cover on the outside of the cell. Next you find a metal can which is made of zinc. Do you notice that one of the binding posts is fastened to this zinc can? A binding post is the place where you fasten a wire to the cell.

Then comes some moist blotting paper and next a black powdery material. Finally, a black rod of carbon is in the center of the cell. The other binding post is fastened to this rod.

Wax, sawdust, and sand were used to seal the dry cell at the top. This sealing is very necessary. A dry

cell will not furnish electrons if it really becomes dry. It is called a dry cell because it is dryer than other cells which furnish electricity.

The storage battery in an automobile is not called a dry cell. Do you know why?

Do you know why each of these parts is necessary in a dry cell?

Richie

A DRY CELL SETS ELECTRONS FREE

Just how are the electrons set free in the dry cell? The zinc can forms the negative (–) pole of the cell. The black carbon rod in the center forms the positive (+) pole. Suppose you are told to fasten a wire to the negative binding post. You know this means the outside screw. And if someone mentions the positive post, you know that he means the center screw.

The black, powdery substance around the carbon rod is a mixture of chemicals. Electrons are set free during the chemical reaction, or action, which takes place between all these things.

Energy is stored up in the chemicals in the dry cell. When the dry cell is put in a circuit, the chemicals begin to act on each other. The stored up chemical energy changes to electrical energy. Electricity is not really made. Chemical energy just changes to electrical energy.

Electrical energy leaves the dry cell as electrons. Electrons are set free and leave the dry cell at the negative binding post on the zinc can. They travel through the wire and return to the positive binding post on the carbon rod.

Some of the energy of the electrons is changed to light and heat energy in the flashlight bulb. Some of it is changed to mechanical, or moving, energy in the electric bell. So, after a time, the dry cell gives up all its electrical energy. When all the electrical energy of a cell has been given up, we say the cell is dead. None

of the electrical energy has been lost. It has just been changed to another kind of energy.

THINGS TO THINK ABOUT

The first electric cell was made in 1797 by Allesandro Volta, an Italian scientist. This was a very important discovery, because it was the first time man had been able to make really useful electricity.

You may like to find out more about Volta and the cell he made. Even though Volta's cell looked different from a modern cell, electrons were set free in exactly the same way.

THINGS TO DO

1. Visit a garage with your father or teacher and ask the garageman to let you see how he charges, or puts electricity into, storage batteries.

2. Make a chemical cell with a lemon. Cut a small piece off the top of a lemon. Put a thin piece of zinc and a thin piece of copper into the lemon. They should be rather close together, but not touching. Touch your tongue to the top of the two pieces of metal. Do you feel a slight electric current? Electrons have been set free by a reaction between the lemon juice, the zinc, and the copper.

Electricity Caused by Friction

HOW DOES FRICTIONAL ELECTRICITY WORK?

Have you ever had your hair snap and crackle when you were combing it? Did it ever stand on end as you pulled the comb through it? Tear up a piece of paper into tiny bits. Pull a comb through your hair again. Now hold the comb near the bits of paper. The comb picks up the pieces of paper and acts something like a magnet.

But do you remember the things that a magnet would pick up? We discovered that magnets would pick up only those things made of iron or steel. The comb picks up paper. Will it pick up iron or steel? Are there other materials it will pick up? Will a true magnet pick up any of these objects?

These surprising things happen not because the comb has become a magnet but because you have been setting electrons free. Electrons can be set free by friction, that is, by rubbing two things together. This is what you may have done. Just rubbing any two objects together will not always set electrons free. It is only when certain objects are rubbed against certain other objects that this happens. The electricity so formed is called frictional electricity.

Frictional electricity has probably surprised you many times. Have you ever walked across a rug on the floor and touched a radiator, a bed, or some other metal object? You may have jumped because you received

a small electric shock. If this happened, you know how frictional electricity feels.

There are other ways of making frictional electricity. Rub your fountain pen across your woolen sweater or coat. Hold the pen near bits of paper which you have

Early Greeks rubbing amber discovered that the amber would attract certain objects

torn up. What happens? Rubbing the hard-rubber pen against the woolen sweater causes frictional electricity.

Rub a glass rod with a piece of silk. Hold the glass rod near the paper. What happens now? Rubbing glass with silk also causes frictional electricity.

The Greeks discovered electricity hundreds of years ago. They were very fond of amber. They used amber to make into beads just as we do. As they rubbed the amber to polish it, they noticed that it attracted certain objects. Our word *electricity* comes from the Greek word *elektron*, meaning "amber."

We do not know exactly what happens when we rub a fountain pen on a piece of wool; however, we do try to explain what happens. This explanation is called a *theory*.

When we spoke of current electricity, we said that it was a movement of electrons. The electrons, negative charges of electricity, can be made to move about. When they move in a path, an electric current is made. Sometimes they leave one object and gather on another. The object on which the electrons gather is said to be charged with negative electricity. There are a great many electrons on it.

When you pulled the comb through your hair, electrons gathered on the comb from your hair. The comb was charged with electricity. The electricity was not very strong. You could not even feel it.

The shock you felt after walking across the rug and touching the radiator showed you that there was some electricity in your hand. It came from the rug over

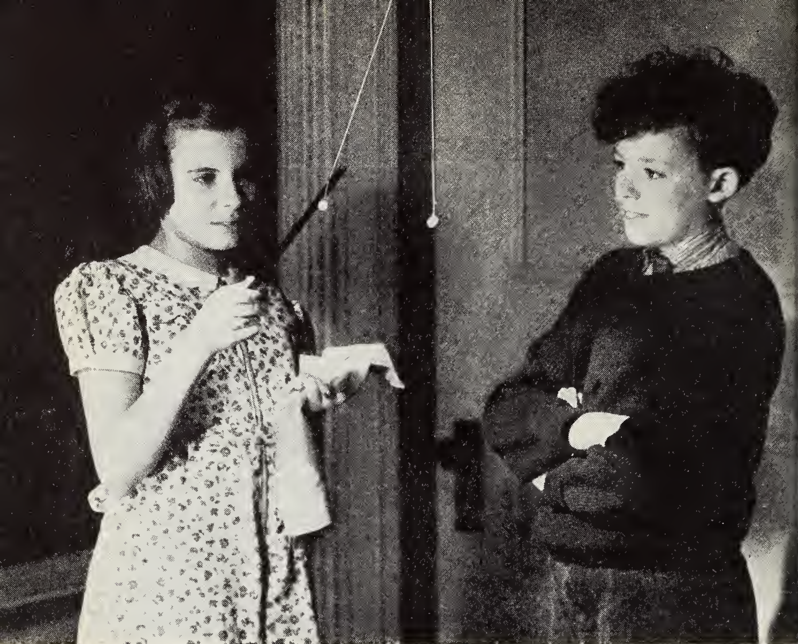
which you rubbed your feet. The electrons left the rug and entered your body. When you touched the radiator, all the electrons left your body through the tip of your finger. Then you felt a shock.

A LAW OF ELECTRICITY

Let us try to explain what happens when we charge objects with electricity. For this experiment you will need two pith balls, some silk thread, a hard-rubber rod or fountain pen, a piece of wool, a glass rod, and a piece of silk. You can get pith from the center of dried cornstalks. Very dry balls of tissue paper or grains of puffed wheat or rice may also be used. Hang the two pith balls by the silk thread from a wooden stick which you have fastened to the wall. You may hang them from anything else which is not a conductor.

Now rub the rubber rod with the wool. Hold it close to the pith balls. Watch carefully. Did you see the balls come to the rod, stick there for a moment, and then fly away?

At first the pith balls were neutral; that is, they had about the same number of positive and negative charges of electricity. Then the rod was rubbed with the wool. The rod's charge became negative, because of the electrons which gathered on it from the wool. When the rod touched the balls, electrons left the rod and gathered on the balls. Both balls now became negatively charged. In other words, there were more negative charges than positive charges on each ball.



Richie

A hard-rubber rod rubbed with wool will attract a pith ball

Since charges of electricity which are alike repel each other, the balls would not stick together.

You can make the balls neutral again by touching them with your hand. The electrons flow into your body, since it is a good conductor.

This experiment will work best on a cool, dry day. If the air is moist, the electrons on the balls will escape into the air. Moist air is a conductor of electricity.

Can you state a law which is something like the law of magnetism? A law which was stated by scientists reads somewhat in this manner: Like charges of elec-

tricity repel; unlike charges attract. Did your experiment show this?

LIGHTNING IS A HUGE ELECTRIC SPARK

You read something about lightning and thunder when you were reading about weather. Lightning is the flow of electrons. It may be within a cloud, between two clouds, or between the earth and a cloud. It is really a giant spark. It is like the spark that you sometimes see when you stroke a cat's fur, except that it is many times greater.

This huge spark may jump from cloud to cloud, from the top of a cloud to the bottom of it, or between the earth and a cloud. The clouds become charged with electricity. Perhaps air currents cause electrons to gather on one cloud or a part of a cloud. We are not really sure about this.

The place where the electrons gather is negatively charged. Another cloud will be left without enough electrons. We say it is positively charged.

When the clouds are near enough, electrons are able to jump from a negatively charged cloud to a positively charged cloud. Then there is a flash of lightning.

DOES ELECTRICITY CAUSE AURORAS?

In the arctic regions the sky during long winter nights is sometimes lighted by the northern lights, or aurora borealis. Sometimes colored lights shoot up; at other times great curtains of beautiful colors seem to cover

© American Museum of Natural History. From a painting by Howard Russell Butler

This aurora was seen from the northern part of Maine

the sky. The antarctic continent has an aurora, too. But the beautiful colors and lights are called the southern lights, or aurora australis.

The exact cause of auroras is not known. However, scientists feel sure that magnetism and electricity have something to do with them. They also know that the auroras are very high in the air that surrounds the earth. It is thought that electrons from the sun produce an aurora when they strike the air around the earth.

Scientists are studying auroras all the time. Polar trips, such as those made by Byrd and Peary, help scientists in their studies. The balloon flights into the upper air or stratosphere are also very valuable.

Some day we shall know more about the real cause of auroras. However, just now we cannot answer our question Does electricity cause auroras? This is one of the many, many things which scientists are not sure about.

THINGS TO THINK ABOUT

1. Have you ever read about Benjamin Franklin's experiment with lightning? He was a man who was curious about many things and worked on and on until he found the answer to some of his questions.

2. New theories about auroras are sometimes given in the newspapers. Some day soon we may have an even better idea of what really causes the auroras.

THINGS TO DO

1. Make a list of all the ways you use electricity every day. Make a list of the ways you use magnetism every day.

2. Write a story about the way people lived before they knew how to change some forms of energy into electrical energy.

3. Perhaps you would like to have a play in two scenes. One scene could show a day or a part of a day in the life of a family which does not have electricity. The other scene could show how electricity helps a family.

All Electricity Is Really the Same

Electricity for use in our homes is made neither by dry cells nor by friction. The machines which make this third kind of electricity are called generators of electricity. Electrons are set in motion within the generator. Electricity then travels over wires to our homes in the same way that it travels in a simple circuit.

The energy of steam or water power is used to keep certain parts of the big generators moving. In these parts are wound wires, known as coils, which are spun around rapidly within the field of huge magnets. This rapid turning sets the electrons within the wires in motion. You know that the movement of electrons through wires is an electric current. The electricity produced by generators is one of the most important kinds of energy that scientists have been able to help us to use.

However, no matter how electric currents are started, they always act in the same way. Electrical energy, whether it is produced by rapidly turning wires within the field of magnets or by chemicals, is changed into other forms of energy. It may be changed into heat energy (as it is used in a toaster), into light energy (as it is used in an electric light), or into energy of motion (as it is used in an electric sewing machine). Man has learned to control and use these kinds of energy.

IX

The Sky

STARS

THE SUN, OUR NEAREST STAR

THE SOLAR SYSTEM

THE STORY OF THE MOON

GALAXIES

PEOPLE have always wondered about what they saw in the sky. Long ago before there were any telescopes to help us find out about the sky, people made up stories about the stars. We know that these stories were not true.

Today we know much more about the things, or bodies, in the sky, because men have spent their lives studying them. Yet it has taken many men hundreds of years to find out what we now know about the sky.

There are many different kinds of bodies in the sky. Some are giant stars, which give out much more heat and light energy than our own sun. Some are moons much like our own. Some are comets, which come close enough sometimes for us to see them. Some are bodies much like our own earth.

In this story we shall see why our star, the sun, is so important to the earth and other bodies like the earth. The picture of the sun, facing page 252, shows sun spots and great streamers of hot gases. The blue circle represents the earth. Do you see how large the sun is?

We shall try to see what forces keep the earth in its place. Then we shall look out beyond our own sun at the millions and millions of stars in the universe. Perhaps we can find answers to other questions about this universe in which we live.

THE PICTURE FACING PAGE 252 IS FROM A PAINTING BY CHARLES BITTINGER.

Stars

WHAT ARE STARS?

Should you like to count the number of stars you see in the sky on a clear dark night? You would soon grow very tired, for you can see about two thousand stars with your naked eye. There are millions and millions of other stars, but they are so far away that you would need a telescope to see them. Even the number of stars that may be seen through telescopes grows larger and larger from year to year. This is because scientists can see more stars as they make better telescopes.

We are told that the stars are always moving in space. A few of them travel in groups, but most of them move alone. The universe is so very great that though the stars travel on and on, they may never come near each other.

Each true star that you see in the sky at night is a sun. Every one of them gives off so much heat energy that no living thing could remain alive on them for a second. Some of them look like tiny specks of light in the sky, but they are really enormous in size. Scientists tell us that a very few of them are just a little larger than the earth. But some of them are big enough to hold hundreds of thousands of earths, with plenty of room left. Sometimes we find a star that is a huge giant. Millions and millions of earths could be put inside it.

You may have noticed that some stars seem to be much brighter than others. You probably have thought

that the brighter ones were much larger than the others. This may not be true. A star may seem to be larger than other stars because it is so much nearer the earth.

Astronomers, or scientists who study the sky, have put the stars into classes according to their brightness. They use the word *magnitude* for the different classes. The ancient people used this word too. The brightest stars are said to be of the first magnitude. Those a little less bright are of the second magnitude, and so on. The stars that may just be seen with the naked eye are of the sixth magnitude. A telescope must be used to see stars that are fainter than those of the sixth magnitude.

All stars that shine in the sky are giving out great amounts of heat and light. You remember that heat and light are kinds of energy. Just think of the amount of energy that is being given off in the sky all the time. Yet these great sources of energy are so very far away from us that only a very little of their energy ever reaches the earth. In fact, the only star that really gives the earth enough heat and light energy to be useful is our own star, the sun.

CONSTELLATIONS OF STARS

Many, many years ago the ancient people began to wonder about the stars. Night after night they looked at the sky and wondered and wondered about them. They imagined the stars to be in groups. Then they imagined they saw the outlines of the figures of their favorite gods and goddesses and heroes in these groups.

The two stars at the right in the Big Dipper point to the North Star

It was easier for them to remember the stars in this way. So they divided the night sky into groups of stars, or constellations. They gave the constellations the names of the gods and goddesses and heroes.

The stars in a constellation may be millions and millions of miles apart. They may not even be close enough to be in the same system, or family. They only seem to us to be close together as we look at them from the earth.

Most people know these two constellations: Ursa Major, or the Great Bear; and Ursa Minor, or the Little Bear. Do you know them? You may know where to look in the sky to find the Big Dipper. The seven stars that make it are in the constellation Ursa Major, or Great Bear. The handle of the Dipper is the bear's tail.

After you have found the Big Dipper, it is very easy for you to find the Little Dipper. It is in the constellation Little Bear. The end star in the handle of the Little Dipper is a very important one. It is the North Star, or Pole Star. This star is almost exactly over the north pole of the earth. The North Star could be seen from the northern part of the earth even in the daytime

if the sun were not so bright. The North Star can be used as a guide all night long because it can be seen in the sky all night by anyone who lives on the northern part of the earth.

If you could watch the Little Dipper all night, you would see it seem to swing around the North Star. It really does not do this at all. It only appears to turn about the North Star because the earth is turning on its axis.

We are not so interested today in giving new names to constellations. Scientists are interested in learning more and more about the stars that make up the constellations. They want to know how far away they are, how they are moving, how large they are, and how much heat energy they give off. All these things help us to know more and more about the universe in which our earth moves.

THINGS TO DO

1. Find the Big Dipper early in the evening. Look at it about an hour later. Why does it seem to change in position?

2. Ask someone to help you to find the constellation Orion. Notice the two very bright stars in Orion. The one above Orion's belt is Betelgeuse. The one below the belt is Rigel. These two stars seem to be fairly close to each other, but Rigel is really much farther away from the earth than Betelgeuse.

The Sun, Our Nearest Star

THE SUN

Although the sun is many times larger than our earth, it is not one of the largest stars. There are other stars that are many, many times larger than the sun, but they look small to us because they are so far away.

Large things always appear small when they are a great distance off. You know how very small an airplane looks when it is flying very high. Large ships look smaller and smaller as they go farther and farther out to sea. They look much smaller than boats of the same size which are still in port. So the sun looks larger to us than other stars because it is nearer than they are.

The sun is one star that you do not see at night. You can see it only in the daytime. And you can see it only on clear days, too. You cannot see the sun at night because the earth is turning on its axis and the place on the earth where you live is turned away from the sun during that part of the day.

The sun is the star that is most important to us. It gives us our heat and light energy. It really gives us our food too. It gives plants the energy that they must have in order to make food and grow; and plants and plant-eating animals are food for us.

The sun does not look much like the stars we see at night. For many, many years people did not know that the sun was a star. It does not look like the other stars because it is so very much nearer to us.

Dick Whittington

his is the Mt. Palomar Observatory in California. The roof turns around and pens so that the stars and planets may be studied with the great telescope inside

Have you ever been in a place where the temperature went up to 90° F. or more during the summer? Do you remember how warm you were? Then think how hot

the temperature of the sun must be. Scientists tell us that the temperature on the surface of the sun is about 10,000° F. We cannot understand what such great heat is like. The thermometers we have in our rooms would not show such a temperature. The mercury or alcohol in the thermometers would turn into gas at such great heat.

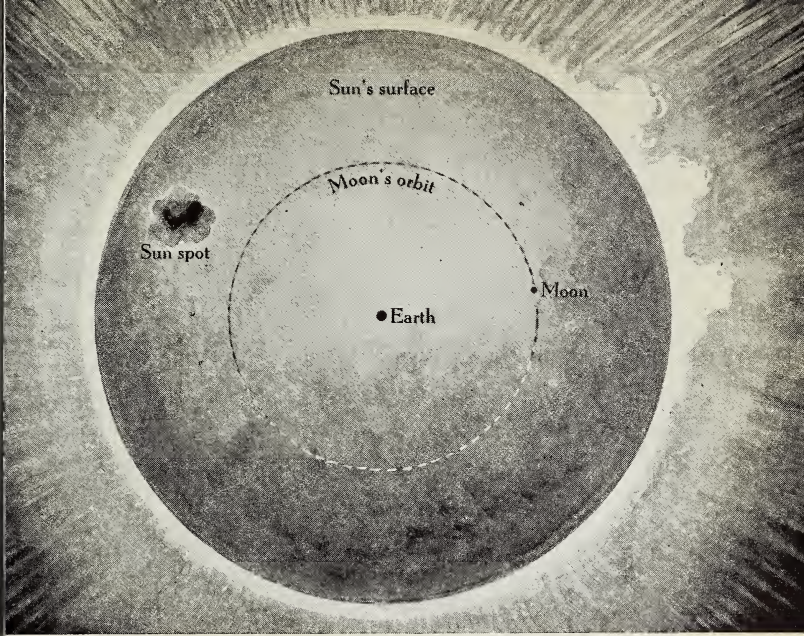
The sun is a great ball of hot gases. These gases are not burning. They are so hot that they give off light. We say they are incandescent. Electric lights do not really burn. They are incandescent, too.

No one could live near such a hot mass of gases as the sun is. It is rather dangerous even to try to look at this shining, bright sun. You may injure your eyes if you do. We know there can be no living thing on such a hot body. But without the sun's light and heat energy there would be no living things such as we know on the earth.

The sun is really only a medium-sized star. It appears larger than other stars because it is only 93,000,000 miles away. Does it seem queer to you to say *only* 93,000,000 miles? Our next nearest star is many hundreds of thousands of times as far away as the sun is. So you see why we say *only.*

Think of this: an automobile, if it could go to the sun, running steadily night and day at the rate of sixty miles an hour, would not reach the sun until a hundred and seventy-five years had passed.

The sun weighs over three hundred thousand times as much as the earth. It is over a million times as large as the earth. The diameter of the sun, or the distance



his may give you some idea of the size of the earth in comparison with the n. Notice that the earth, the moon, and the distance between the earth and moon could all be put inside the sun

through it, is 864,000 miles. This is one hundred and nine times the earth's diameter. Very likely you have never used such large numbers. They are so great that it is difficult even to think of them and to try to understand what they mean.

It may be easier for you to get an idea of the size of the sun and the earth in this way. Think of the sun as a large basketball. Then think of placing a very small-sized pea on it. The pea represents the earth. Again, if we could put the earth in the middle of the sun, the

moon would be able to move around the earth 240,000 miles away. Even then the moon would not be more than halfway to the surface of the sun.

LIGHT YEARS

Scientists have measured the distance from the earth to the sun. They have also measured the distance between the earth and other stars. The measures they use for finding distance to stars are different from the measures that we use for finding distance on the earth. They use "light years." A light year is the distance a ray of light travels in one year.

You know that light waves travel much faster than sound waves. Light travels 186,000 miles in a second. Traveling at the great speed of 186,000 miles in a second, a ray of light can go a distance equal to the distance around the earth seven times in one second.

After a ray of light leaves the sun, it takes only about eight minutes for it to reach the earth.

SUN SPOTS

Astronomers who look at the sun through their telescopes tell us that they often see dark spots on it. These dark places are called sun spots.

Sometimes sun spots look very dark, almost black, in color. They have rough edges. They differ greatly in size. Some of them are only 500 miles in diameter. Others, however, are 50,000 miles in diameter. That means that some of them may be about six times the

earth's diameter of about 8000 miles. The earth could easily fit into some sun spots.

Scientists are not sure what it is that causes these spots. They believe that sun spots are whirling masses of hot gases. These gases are thrown or whirled up from some part of the inside of the sun. When they reach the surface they become cooler. Cooling makes them look dark as compared with the rest of the sun. So they look like spots.

Some sun spots last only a day. There are times when no spots can be seen on the sun; but there are other times when there are many sun spots.

Sun spots have helped scientists to find out how fast the sun is rotating, or turning, on its axis. They have found that a spot near the middle of the sun turns all the way round once in twenty-five days, while a spot near one of the sun's poles turns round once in thirty days. So it would seem that not all places on the sun rotate at the same rate of speed.

Sun spots also affect the earth. There are times when their magnetic power causes great disturbances. As you have already learned, they may cause northern and southern lights.

When there are many sun spots, the magnetic needle of the compass does not always point in the right direction. When the sun seems free from spots, the needle is much more regular. Sun spots also seem to affect radio waves. Some radio programs are sometimes hard to hear when there are many sun spots.

THINGS TO THINK ABOUT

1. Even though ships have compasses and radios to guide them, they sometimes check their position by the North Star. Why can they do this?

2. Do you think it would be a good thing if the sun were as near to us as the moon is?

or

Do you think it would be a good thing if the sun were only as near to us as the next nearest star?

3. Scientists tell us that all the stars are moving around in space. They are moving very rapidly in many different directions.

Why do you think they never bump into each other?

Why do you think we cannot see them moving?

The Solar System

THE PLANETS

Scientists think that long ago when the sun was young something happened to it so that parts were separated from it. These parts began to move around the sun, from which they had come; and they have been moving around it ever since. These parts are now called planets. The sun and the planets that revolve, or travel, around it make up the solar system, or the sun's family.

Although the planets probably came from the sun, they are not like it. They have no light and heat energy of their own. They shine in the sky, but they shine by the light which they reflect from the sun.

When we see them at night they look quite steady. They do not seem to twinkle as the stars do. Since the planets are a part of the sun's family, they are not even near the other stars. They only seem to be near them.

Long ago the early people noticed that the planets did not stay in the same place. So they gave them the name of wanderers, or planets.

Nine planets have been discovered. They are Mercury, Venus, the earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Pluto was discovered only a few years ago. Some astronomers think there may be more planets out beyond Pluto.

Besides these nine most important planets there are a large number of small bodies called asteroids. These are really planets, too.

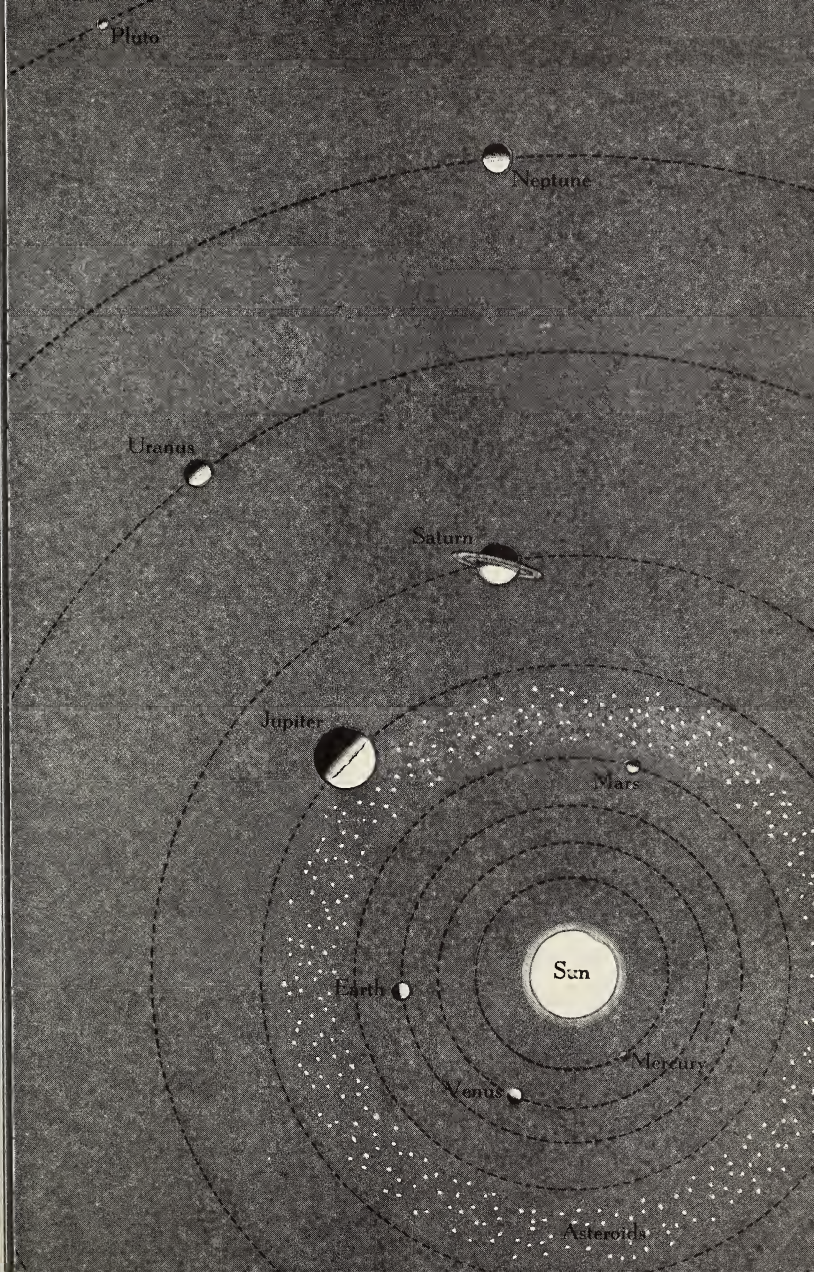
Most of the planets have smaller bodies that go around them while they themselves are revolving around the sun. These small bodies are satellites, or moons. Our earth has one moon. Some of the planets have more moons than the earth. Some of them have no moons. Saturn has nine.

Each planet moves smoothly in its orbit, or path. There is no jarring, no jolting, no getting into the way of another planet.

Why do the planets move? Scientists think that long, long ago, so long ago that we do not even try to think how long ago it was, something happened to put the planets in motion. Once they were moving, no force was needed to keep them moving. Machines will stop running unless some force keeps driving them, but that is not true in the solar system. The planets swing along with the sun year after year.

Why are the planets always able to stay in their own orbits? The sun is in the center, or middle, of its family. It is many, many times larger than the largest planet in the group. Because the sun is so large and so near, it has great power to attract its family. Each member must remain and move in its own orbit because the sun keeps it there. This powerful attraction which the sun has for its family is called gravitation.

Are your brothers and sisters like you in every way? Members of a family usually differ in many ways. This is true of the sun's family, too. The planets are quite different from one another. Some are large, while others are small. Some have satellites, or moons, following


Pluto
Neptune
Uranus
Saturn
Jupiter
Mars
Earth
Sun
Mercury
Venus
Asteroids

them about, while others have no moons. Some stay near the sun, while others are so far away that the sun would look like any other large star from them. The next stories will tell you about the ways in which planets differ from one another.

THE SMALLER PLANETS

Mercury. If we could start at the sun and travel away from it, visiting the planets, Mercury would be the first planet we should come to. It is the one nearest the sun.

Mercury is so near the sun that we can see it only just after sunset or just before sunrise. We cannot see it often. When we do see it, we call it the evening star or the morning star. Of course, it is not a star at all.

Mercury is the smallest of the nine known planets. Its diameter is only about three thousand miles. It is much smaller than the earth. Do you remember how large the diameter of the earth is? How many times larger is the earth's diameter than Mercury's?

Other planets do not have the same length of year that we do. A year on any planet is the length of time it takes that planet to go around the sun. A day and night on any planet is the number of hours it takes that planet to turn all the way around on its axis. A year on the earth is three hundred and sixty-five and a quarter days. A day and a night on the earth is twenty-four hours long.

Mercury has the shortest year of all the planets. It is so near the sun that it does not have such a long path,

or orbit, around it. So it goes over its orbit in a very short time. It takes only eighty-eight of our days for Mercury to go all the way around the sun. A year on Mercury, then, is only eighty-eight of our days. If you lived on Mercury, you would have a birthday every eighty-eight days. Think of having four birthdays in one of our years!

Astronomers think that Mercury turns on its axis only once every year. If this is true, the day on Mercury would be just as long as the year. One side of the planet would always face the sun. It would always be day on that side. Think how hot it would be.

The other side of Mercury would be turned away from the sun. It would always be night there, and it would be very, very cold.

Mercury is so near the sun that it gets more heat and light energy from it than any other planet. Do you think you would like to live on a body that received so much heat and light energy?

Astronomers have no reason to believe that there is any life on Mercury. They think there is no air or water there. So none of the living things that we know about could live there.

Venus. Leaving Mercury, we would make the next stop on our trip away from the sun at Venus. This planet is almost twice as far away from the sun as Mercury is.

Venus is a very beautiful planet. It is much larger than Mercury. It is only a little smaller than our earth.

Sometimes it has been called the earth's sister planet. Some scientists think it is much like the earth in climate.

It is the planet that is nearest the earth, too. It is near enough so that astronomers could study it carefully, if it were not surrounded by such dense, thick clouds. Astronomers have not been able to see through these clouds. Some day the clouds may become thinner or disappear. Then we shall be able to find out more about Venus.

So we know little about Venus, although it is our neighbor. We cannot tell whether it has oceans and land or whether it has any life. Scientists have had great difficulty in finding out how long the days and nights are.

If we look at Venus through a telescope, it seems to have different shapes, as the moon does. It does not always look round. It is the planet best known as the evening star or as the morning star.

Mars. The next planet away from the sun is the earth. But we live on the earth and know many things about it. So we shall continue our journey on to Mars.

Mars is much smaller than our earth. Its diameter is only half the diameter of the earth. It is about four times as far away from the sun as Mercury is. When we see Mars in the sky at night its color is red.

Some scientists think there may be life on Mars. Others think there is no life on it. Some say that Mars has everything that is necessary for life. But we do not know whether or not people could live on the planet.

Mars seems to have very few clouds. Lines, or streaks, have been seen on its surface. Some persons have thought that these lines are canals which have been built by people like ourselves. If they are canals, they must be very, very wide—over a hundred miles across.

Other persons have thought that these lines are plants growing along streams of water.

Slipher, from Lowell Observatory

Venus often has one of these shapes when seen through a telescope. Can you tell why?

Besides the lines, or streaks, which have been seen on Mars, there is also a wide dark belt in the tropical region of the planet. This dark belt is believed to be an area of land covered with plant life.

Mars is thought to have four seasons, like the earth, although very likely it is no warmer at noon on the equator of Mars than it is in St. Louis or Kansas City in October or November. There are places around the poles on this planet that are white. These are thought to be snowcapped. In summer these white places seem to grow smaller, as if they were melting ice or snow.

Astronomers agree upon a number of things about Mars. They know that it takes Mars almost twice as long to go around the sun as it takes the earth; that is, a year on Mars is as long as about two of our years.

Drawing by Lowell, from Lowell Observatory

This is a drawing of Mars. No one has ever made a photograph that looks like this

Astronomers also know that a day on Mars is a little more than twenty-four hours long, and that Mars has two small moons, each of which is less than twenty miles in diameter.

Asteroids. The asteroids are a group of small bodies that travel around the sun, too. So they are members of the solar system. There are about fifteen hundred of them. Most of them are less than sixty miles in diameter. You could walk around most of these little bodies.

The orbits of the asteroids are between those of Mars and Jupiter. They act like the large planets, and astronomers call them planets, too. The greatest difference between them and the other planets is in their size, for they are many times smaller than the other planets.

Some of the asteroids would be large enough only for a large farm. But on our journey through the solar system we should not care to stop and farm them. They would be solid rock with no soil. So we could not expect to raise anything on an asteroid farm. Then, too, there would be no air to breathe.

Jupiter. Next comes Jupiter, the great giant planet of the solar system. Jupiter weighs more than any of the other planets. It weighs about three hundred and seventeen times as much as the earth. The diameter of Jupiter is about 88,000 miles, while the earth's diameter is only about 8000 miles.

Even though Jupiter is such a giant planet, it does not look so bright as Venus. This is because Jupiter is so much farther away from us than Venus. Sometimes in the evening you can see both Jupiter and Venus in the western sky. The bright planet high in the sky is Jupiter. Venus is so near the sun that it is seldom seen high in the sky.

Jupiter has nine satellites, or moons. Four of these moons are very large. The two larger ones are each about the size of the planet Mercury; the two smaller ones are about the size of our moon. Astronomers have been observing these moons for many years.

Jupiter has marks like belts on its surface. Astronomers think these are clouds of gases. They are brown, yellow, red, green, and tan in color. One large red spot on the surface of the planet has been of much interest to astronomers.

Because of the clouds around Jupiter, astronomers are not able to see the surface of the planet. It receives much less heat and light energy than the earth, because it is so far away from the sun.

If you lived on Jupiter you would not grow old in


Slipher, from Lowell Observatory
This photograph of Jupiter shows the great belts of gas around it

years very fast. You would have a birthday only once in twelve of our years. If you like birthday parties you would not care to live on this planet. Jupiter is five times as far away from the sun as the earth is. So it has a much longer path to travel around the sun. A day on Jupiter is very short. It is only ten hours long.

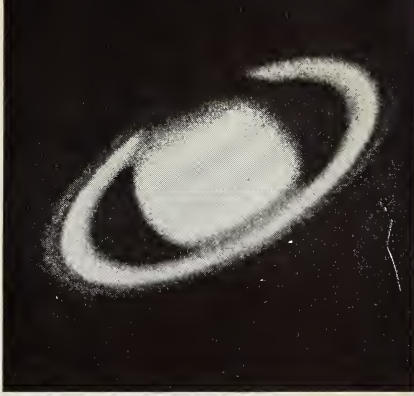
Saturn. Now we stop at Saturn. Saturn is next to Jupiter in size, since it is about 75,000 miles in diameter. It is about ten times as far away from the sun as the earth is.

Saturn is said to be the third brightest planet. It is colder than Jupiter. Its year is about equal to thirty of our years. It rotates on its axis in a little more than ten hours. So its day is a little more than ten hours long.

The rings around Saturn are very interesting. No other planet has rings. These rings are thin and flat. They seem to be made up of many very tiny pieces that reflect the light of the sun. Besides its rings, Saturn has nine satellites, or moons.

Uranus. The first six planets that you come to as you go away from the sun were known to men who studied the sky as long as three thousand years ago.

The other three planets have been discovered during the last two hundred years. Uranus, the seventh planet as we travel from the sun, was discovered in 1781.



Barnard, from Mount Wilson Observatory

Saturn is the only planet that has rings

Uranus is the third planet in size, since its diameter is about 32,000 miles. But it is about nineteen times as far away from the sun as the earth is. It can just barely be seen with the naked eye on a dark night. It looks like one of the faintest stars in the sky. It is not near enough to be easily studied.

We do know that it takes Uranus eighty-four of our years to make one trip around the sun. Uranus has four moons. It is a very cold planet, because it is so far away from the sun.

Neptune. Neptune was discovered in 1846 in this way: Scientists know that all bodies have gravitation. They also know how much one body attracts another. It was noticed that Uranus was being pulled out of its regular path around the sun. Two young men used their knowledge of mathematics to find out how much it was being attracted, or pulled. By more work in mathematics they were able to tell about where the object should be that was pulling Uranus out of its path. They told other astronomers where to look for it. Using their

telescopes, the other astronomers looked for and found the planet we call Neptune close to the place where the scientists had said it would be. Is it not strange to think that scientists, with pencil, paper, mathematics, and the knowledge that other scientists have furnished, can sit at a desk and tell where a planet is?

Very little is known about Neptune, except that its year is one hundred and sixty-five times our year and its diameter is about 31,000 miles. It is so far away that it can be seen only with a telescope. It must be very cold on Neptune.

Pluto. Pluto, the ninth planet, and Neptune were discovered in much the same way. A number of years ago Dr. Lowell, at Flagstaff, Arizona, used mathematics to find out where such a planet should be found, but it took a long time to find it. Pluto was found by taking photographs of a certain part of the sky until a moving speck of light was seen. This speck of light was in different positions in different photographs. It turned out to be the planet we call Pluto.

This planet has not been known long enough for scientists to tell many things about it. They think the distance from Pluto to the sun is thirty-nine times the distance from the earth to the sun. Of course we should not be able to see Pluto without a telescope. Its year is at least two hundred and forty-eight of our years. It is so far away that if we were able to travel out to it, the sun would look to us like any other brilliant star.

Do you think you should like to live on Pluto? Your

days would not be very bright. You might not be comfortable.

Think how cold it would be on a planet so far away from the sun! Scientists think it would be so cold that the gases oxygen and nitrogen would change to solids. So we should not be able to stay there even if we wanted to.

Lampland, from Lowell Observatory

The small spot marked by the two arrows is Pluto. The stars, including the large one, are millions and millions of miles out beyond Pluto

Some of our great astronomers think that there may be more planets out beyond Pluto, because certain of the planets are pulled out of their regular path a little as they go about the sun. You may read about their discovery some day; that is, if they are really there.

OTHER MEMBERS OF THE SOLAR SYSTEM

Shooting Stars. When you were looking at the heavens on a clear, dark night, did you ever see stars suddenly shoot across the sky and disappear?

They were not really stars that you saw; they were meteors. Most people call them shooting stars. Some nights a great many meteors can be seen. There are so many of them that they seem to be in swarms. It is said that millions and millions of them dart into the earth's atmosphere every day.

Meteors are small, solid bodies like rocks. Some of them are very tiny. Others are large enough to weigh several tons. Most meteors are not larger than a walnut. Some are iron, nickel, and stone. Others are almost all stone.

Meteors belong to the sun's family. They too revolve around the sun in orbits as planets do. It happens that their orbits often cross the earth's orbit. Then we see

This large meteorite is in the Hayden Planetarium in New York City.
Most meteors burn up before they come to the solid part of the earth

Doris Day

them. They dash toward the earth with great speed. When they reach our atmosphere their rubbing against the air causes them to become very, very hot. Then they give off light and appear as shooting stars in the sky. We do not see meteors until they enter the earth's atmosphere and become hot enough to give out light. Usually the smaller meteors give off a flash of light and are burned to dust or vapor in a moment.

Sometimes meteors are so large that they go right through the atmosphere and fall on the solid part of the earth. Then they are called meteorites, not meteors. Many of the meteorites are kept in museums.

Some astronomers think that meteors may be small, scattered parts of comets' tails.

Comets. The word *comet* comes from a Greek word that means "long-haired." That seems to be a good name for these members of the sun's family, for they have a head with a tail streaming out from it. Some comets have more than one tail. The tails may be short, or they may be very, very long.

Comets remind us of a person who is coming into the presence of a king or queen. He is always very careful to keep his face toward the monarch. He backs out of the room when he is leaving. So it is with comets. The head is always toward the sun. When leaving they back away, the tails going first. The comets' tails always stream away from the sun. This is caused by the force of the energy that comes from the sun. Sometimes these tails break up into small pieces.

Lowell Observatory

This is Halley's comet.

This comet was seen in 1910 and will be seen again in 198

Years ago it was thought that comets were only visitors. But now we know they are probably members of the sun's family all the time, although they may travel a long way from the sun.

One of the most famous comets known is Halley's comet. It is named for the Englishman who discovered it. It may be seen every seventy-six years, because it takes the comet that length of time to revolve around the sun. It last appeared in the year 1910. When should it appear again?

THINGS TO THINK ABOUT

A long time ago, a famous astronomer, Sir John Herschel, gave us something to think about when he suggested how we might get an idea of the size of the solar system. You might like to work out his idea.

He suggested that we use a very large ball, about two feet across, to represent the sun. At a little over 80 feet away put a mustard seed for Mercury. Venus would be represented by a pea 140 feet away. Another pea, 215 feet away from the big ball, would be the earth. Mars would be something much smaller, 325 feet away. Jupiter would be a small orange nearly a quarter of a mile off from the two-foot ball, and Neptune would be a plum at about a mile and a quarter. We might add a small pea for Pluto, which was discovered only a short time ago, and put it at a little less than two miles from the ball. Of course you could have only the sun, Mercury, Venus, the earth, and Mars in your solar system.

What about the stars? Where should you put another large ball to represent one of them? Herschel found that you would have to put this ball 8000 miles away, or as far as the distance through the earth.

The Story of the Moon

WHAT IS THE MOON?

In the very earliest times people worshiped the objects which they saw in the sky. They worshiped the heavenly bodies because their bright lights filled them with wonder and fear. They wanted to know more about the moon. Because they observed it so much, they did learn many things about it.

Today some astronomers think that at one time in the past the earth and the moon were one body, and that some great force caused the moon to separate from the earth.

Although the moon may have separated from the earth, it did not go very far away. It is the nearest neighbor the earth has. It still belongs to the earth. It is the earth's satellite. Wherever the earth goes, the moon also goes.

To the people on the earth the moon looks to be as large as the sun. That is because the moon is so much nearer the earth than the sun is. As we have learned, the sun is 93,000,000 miles away from the earth. The moon is only 240,000 miles away.

Compared with the size of the sun, the moon is very, very tiny. It is small compared with the earth also. The diameter of the moon, or the distance through it, is only 2160 miles. The distance through the earth is about four time as much. The sun's diameter is very great. It is 864,000 miles.

Mount Wilson Observatory

The rough spots are high mountains on the surface of the moon

How we should miss the moonlight nights if anything happened to our moon! It seems strange to think that the brilliant light that comes to us from the moon comes from a body that has no light of its own. The moon merely reflects the light of the sun, that is, it throws back to us the light which it receives from the sun. This reflected light shone on the earth before there were human beings living here.

Scientists tell us that the sun gives the earth more light in a half minute than the moon gives by reflection in a year.

This is the way we think the surface of the moon looks. The earth would loo
like a very large moon in the sky. (From a painting by Howard Russell Butler

We know that the earth and the other planets reflect light from the sun, too. You know how bright a moonlight night on the earth is. Suppose it were possible for you to live on the moon. Think how bright an earth-

light night would be there! The earth, being larger than the moon, would reflect much more light. The full earth would be far more brilliant than the full moon.

Do you think there is any life on the moon?

Plants and animals could not possibly live on the moon. They need air and water. The moon has no atmosphere and no rain or water. It has no soil. It has no forests. Plants would not be able to make food. Without plants there could be no animals. There seems to be nothing on the moon but rock and more rock.

There is only one day and one night on the moon while we are having about thirty days and nights. Think how very hot the days must be! Think how very cold the nights must be!

Astronomers have looked at and studied the moon through large telescopes. They tell us that the surface seems to be rock. It appears to be quite rough and uneven, though some great plains can also be seen. There are mountain ranges with some very high peaks. The mountain sides are steep, because there is no water and therefore no wearing away of the rocks. There are many large holes, or craters, which can be seen even with a small telescope. Some of these craters measure one hundred miles across and are over three miles deep.

When we look at the face of the shining moon without a telescope, we see dark places on it. Some parts of the moon's surface reflect more light than others; therefore some parts are brighter and some are darker. People often imagine the darker places to be the eyes, nose, and mouth of a man's or a woman's face.

CHANGES IN THE MOON'S APPEARANCE

Does the moon always look the same to you when you see it in the sky?

A most unusual thing about the moon is that it does not always look the same. It seems to change its shape. Sometimes it seems to be just a thin sliver. We call this the crescent moon. Sometimes it shines full and round. At other times it seems to be just a half-moon.

We have said that the moon has no light of its own, but reflects the light received from the sun. The half of the moon that faces the sun is always light. But we on the earth cannot always see all the half of the moon that the sun lights up. Sometimes most of the lighted part of the moon is turned away from the earth. Then we see only the edge lighted. This is the thin crescent, or new moon. This happens when the moon, in its path, is between the earth and the sun. The new moon always appears low in the western sky after the sun has set.

As the moon continues its journey around the earth, it arrives at different places in its orbit. Its position with reference to the sun and the earth then changes. It is not always in line with them. Each night, after new moon, more and more of its lighted surface may be seen. When we see half the lighted part of the moon, we call it the first quarter. It looks like a half-moon to us. It is really half of the lighted half of the moon, or one quarter of the whole moon.

After we have seen the first quarter, we see more and more of the lighted face until the full moon appears.

Ve see a crescent moon when we ee only part of the moon brightly lighted

Yerkes Observatory

Sometimes the whole surface of the moon is lighted and we call it a full moon

It may be seen about two weeks after the new moon. At this time the moon is on the side of the earth away from the sun. The moon rises about fifty minutes later each night.

The moon does not remain full very long. It goes on its way around the earth, and we begin to see less and less of the lighted part. Once again a half-moon appears. Now it is the last quarter we see. The lighted part of the moon is growing smaller in size. It is not so brilliant as it was. Then it finally disappears, and we see no moon.

But soon the crescent moon comes again in the west. These monthly changes in the appearance of the moon are called the phases of the moon.

The picture on the next page may help you to work out an experiment which will show what makes the phases of the moon.

WHY WE ALWAYS SEE THE SAME SIDE OF THE MOON

The moon seems to look different because it is always moving. It revolves, or travels, around the earth. It also turns on its axis, but it does this only once in going once around the earth. That is a strange thing about the moon. Because it turns only once on its axis in going once around the earth, we always see the same side, or face, of the moon. We have never seen its other side. It takes the moon a little less than one month to complete both its journey around the earth and its rotation on its axis.

If you wish to experiment a little, stand in the middle of a room. Imagine that you are the earth. Hold a ball or orange in your hand. Stretch your arm out to its full length, still holding the ball or orange in your hand. Rotate, or turn, your body all the way around. While you are doing this, notice that you always see the same side of the ball or orange. If there are other people in

As the girl turns around she can see all the phases of the moon

Richie

the room they may see all sides of the ball or orange as you turn around; but you, the earth, do not.

Do you see why the same face of the moon is always turned toward the earth?

TIDES

You may have heard people say, "The tide is coming in" or "The tide is going out."

The water of the ocean rises and falls at regular hours each day. This regular rising of the water is called flood tide. The falling water is ebb tide.

It seems queer to think that the moon, which is so far away, has anything to do with the rising and falling of the water of the ocean. But it has a great deal to do with it.

Scientists know how the force of gravitation in our solar system acts, and what it does. They know the earth weighs over eighty times as much as the moon. The force of gravity is six times as great on the earth as on the moon. If you could jump six feet high on the earth, you would be able to jump thirty-six feet high on the moon.

The earth and the moon attract each other. The earth and the sun also attract each other. The attraction which the sun has for the earth helps to cause the tides, but the moon is so much nearer the earth than the sun that it has much more to do with the tides. The rotation of the earth on its axis helps to make the tides move about on the earth.

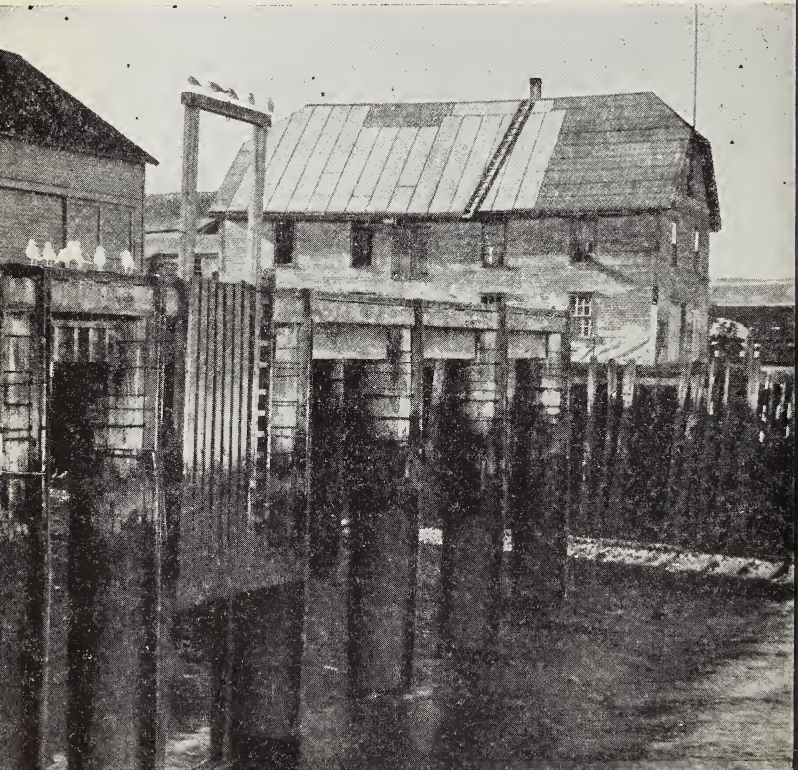
Even the ancient Greeks and Romans knew that the moon had something to do with causing the tides. They spent much time trying to find out how the moon caused the water to rise and fall.

The moon also pulls on the solid part of the earth. We do not realize this, however, because the movement of the solid part of the earth is so very small. Scientists have accurate ways of measuring this pull.

This picture was taken at ebb tide.

Do you see how high the water rises at flood tide?

Cushing



THINGS TO THINK ABOUT

1. If the earth had more than one moon, as some of the planets have, what do you think the night would be like? Would much more of the heat and light energy of the sun be reflected to the earth?

2. Does it seem strange to you to think that the moon has an influence on the trade of the world? How does it do this?

3. How do you suppose the moon might have become separated from the earth, if it did that?

THINGS TO DO

1. Here is a problem in arithmetic for you. Can you do it?

If the sun is 93,000,000 miles away from the earth, and the moon 240,000 miles away, how much farther away is the sun than the moon?

2. A more difficult problem for you would be to find out how many *times* farther away from the earth the sun is than the moon. Do this problem by long division.

3. It takes light about eight minutes to come to us from the sun. You remember that light travels about 186,000 miles a second.

Can you tell how long it takes light to come to us from the moon?

How much nearer the moon is to us than the sun is!

Galaxies

All of us have seen the great band of stars called the Milky Way stretching across the sky. The Greeks, Romans, American Indians, and other people have told myths, or stories, about these stars just as they have told myths about the constellations. Perhaps you know some of them.

The Milky Way is a different kind of group of stars from the constellations. A group of stars like the Milky Way is called a galaxy. A galaxy is a real family of stars which moves along together in space. It is an island of stars in the universe. There are many galaxies.

Our galaxy, the Milky Way, is made up of millions of stars, one of which is our own sun. The solar system is a very small part of this galaxy. The sun, and of course our whole solar system, is moving along with the stars in the Milky Way. All the stars in any galaxy stay together in a kind of star family.

Our galaxy is shaped something like a watch. It is flat and oval. The solar system is between the center and the edge of the galaxy. So when we look toward the far edge of the galaxy, we see a band of stars stretching across the sky.

Each of the many galaxies in space is made up of millions of stars. Some of these galaxies are so very, very far away from the Milky Way that they appear to be single stars. Astronomers think that there may be even more galaxies which are so distant that our telescopes are not strong enough to let us see them.

Yerkes Observatory

This great nebula is far, far beyond the other stars in the picture

THINGS TO THINK ABOUT

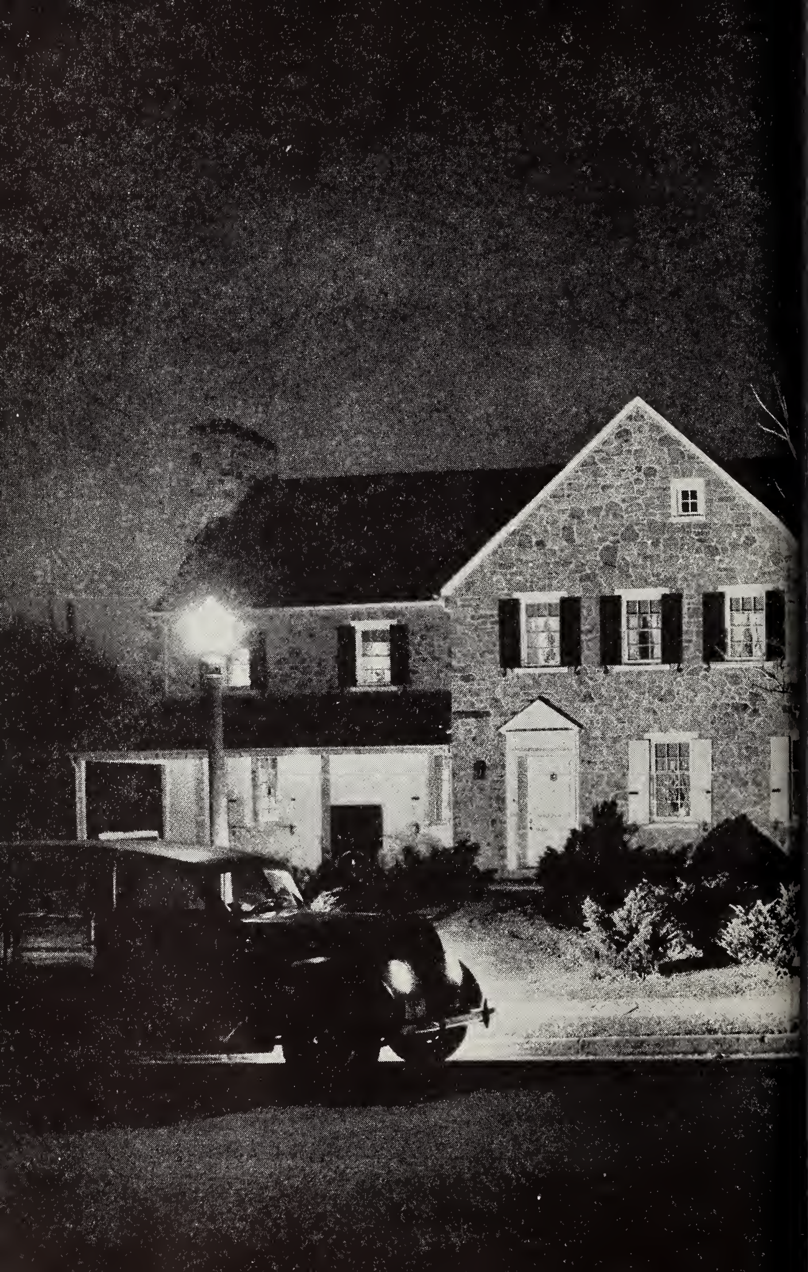
Think of all the many stars in the universe. They are all moving, but they are so far apart that there is no danger of any one of them coming near another for a long, long time.

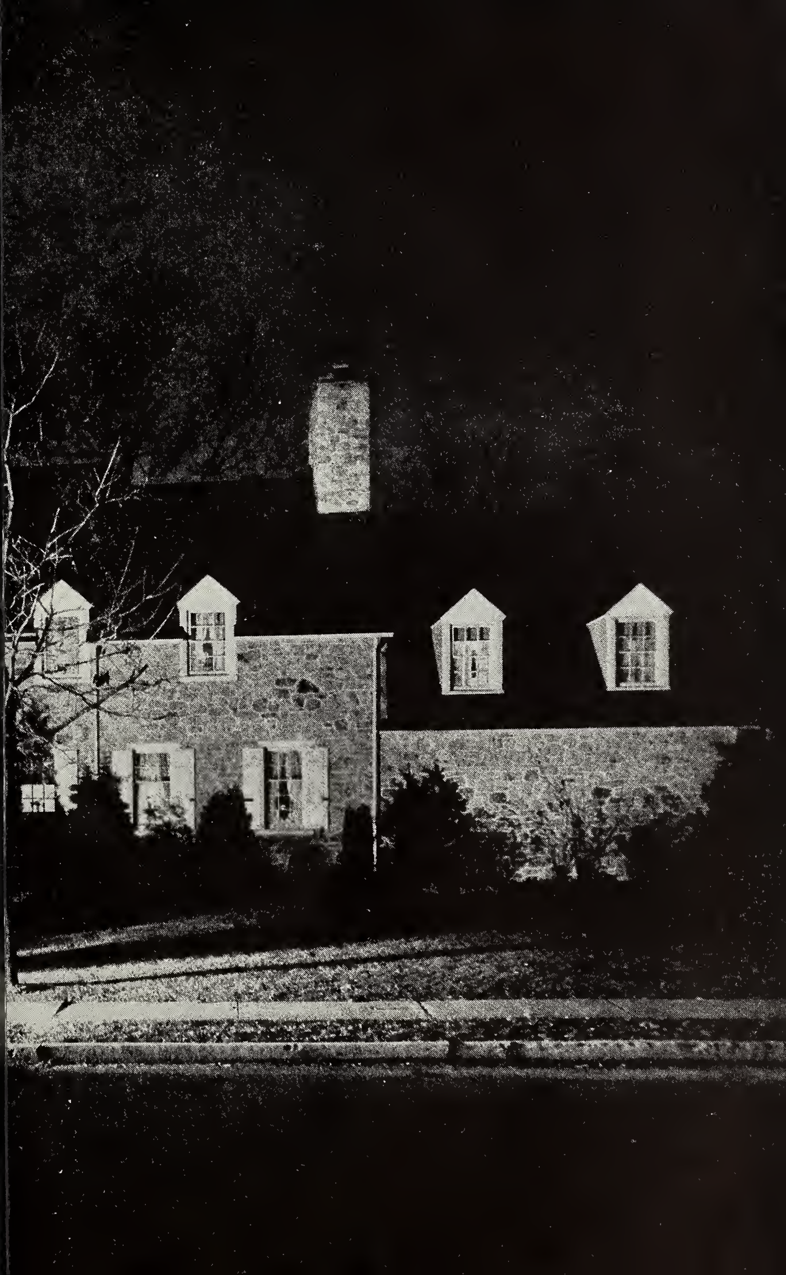
X

Conservation of Energy Resources

SOURCES OF ENERGY

CONSERVATION IS OUR BUSINESS





CONSERVATION is a word we hear more and more every day. Perhaps the best way to think of conserving anything is to think of using it wisely.

All of us are interested in conserving our forests. Cutting down too many of our trees causes floods and makes the land bad for farming.

For several years we have had laws which have helped to save our wild flowers and our birds. Your state probably has laws which say that certain flowers may not be picked and that certain animals may not be killed.

Recently we have started to think of conserving many other things which are found on or in the earth. The picture on pages 296 and 297 showing the lighted house might help you to think of some ways we use energy. Have you ever thought about whether or not we are wasting such things as coal when we use too much electricity? We need electricity, but sometimes we could make it more wisely. The following pages tell you about some of the things which we are beginning to use more wisely.

Sources of Energy

WHAT ARE ENERGY RESOURCES?

The nearest star, our sun, gives so much energy to the earth that it is hard to imagine the amount. This energy is in the form of heat and light. You know that it is very easy to get a bad sunburn from this energy on a hot summer day because of this great heat and light.

We do not know very much about putting the heat and light energy of the sun to work. Men are working on this problem all the time.

The energy of the sunlight which comes to the earth in one minute is so great that it could be enough to furnish all the people on the earth with heat and power for a whole year. Just think of the amount of energy which we have but cannot use!

Scientists tell us that the sun will probably continue to give off great amounts of energy for thousands and thousands of years.

People who live in warm countries make use of this energy for heat all the year round. People who live in cooler countries can depend on the sun for heat only a part of the year. No one is able to change the sun's heat or light energy directly into electrical energy. There is no automobile that can use energy as it comes from the sun. Automobiles cannot catch the sun's energy and use it immediately to run the motor. If there were such an automobile it would not run on rainy days or at night.

There are some things on the earth from which we can get energy for lighting our homes, running our trains, or heating our schools. Those things from which we get energy are called the energy resources of the earth. Energy resources are not new to any of us. We use them so much that we do not often stop to think about them.

Wood, gas, oil, and coal are energy resources. The energy we get from them is used to warm our houses or cook our food.

Swiftly moving water is an energy resource. It has great power to move things. It can turn the wheels of machines in great power plants which give us electrical energy. Can you think of ways that we use electrical energy?

Gasoline, oil, coal, and wood are the energy resources from which we get the energy to run engines in our factories, our boats, our trains, or our automobiles.

Some of our scientists are becoming very much worried about the way we are using these sources of energy. They warn us that we cannot expect the supply of coal, oil, and wood to last forever.

COAL A STOREHOUSE OF ENERGY

Man cannot make coal such as we find in our mines today. He can make charcoal by burning wood, but this is not good for heating our homes or running our trains.

Coal is really a storehouse of the sunlight. Ages ago tropical forests grew much farther north and south than they do now. They may have grown on the

Rittase

Coal-miners must make the tunnels safe as they dig farther into the earth. Can you see the layers in the coal? How do you think this happened

Antarctic Continent and certainly grew within the arctic circle. Energy from the sun made those ancient fern forests grow, just as it makes our forests grow today.

Thousands of these great fern trees fell to the earth and were buried. Other fern forests grew on top of them and were buried. This went on for many, many years. The buried trees were pressed closer and closer together until they turned black and hard. Now we dig these ancient trees up and call them coal.

Scientists tell us that it takes hundreds of years to make a layer of coal only two feet thick. Some veins of coal are a hundred feet thick.

The best kind of coal for heating is a very hard coal called anthracite. This is the best kind of coal because very little of it is wasted in smoke. Most of it can be changed into heat energy which can be used in many ways. We use a great deal of anthracite every year. In fact, if we continue to use as much as we do, we shall have no more anthracite in about a hundred years.

The world is fortunate in having a fairly large supply of soft coal. This coal gives off more smoke when it burns. A ton of this soft coal will not give off so much heat when it burns as a ton of anthracite will. However, the people who live after us will probably have no other coal to use.

The people of North America seem to use more and more coal each year. If we use only 1 per cent more coal each year, our coal will last for less than nine hundred years. You may think that nine hundred years is quite a long time. It is not a very long time though when we think about the number of years man will probably go on living on the earth. People will probably live on the North American continent for thousands of years. What will they do for coal?

No one would think of stopping the use of coal. That would not be sensible. The thing we must do is to use our coal more wisely. We call this conservation of our coal resources.

Coal may be conserved in many ways. A great deal

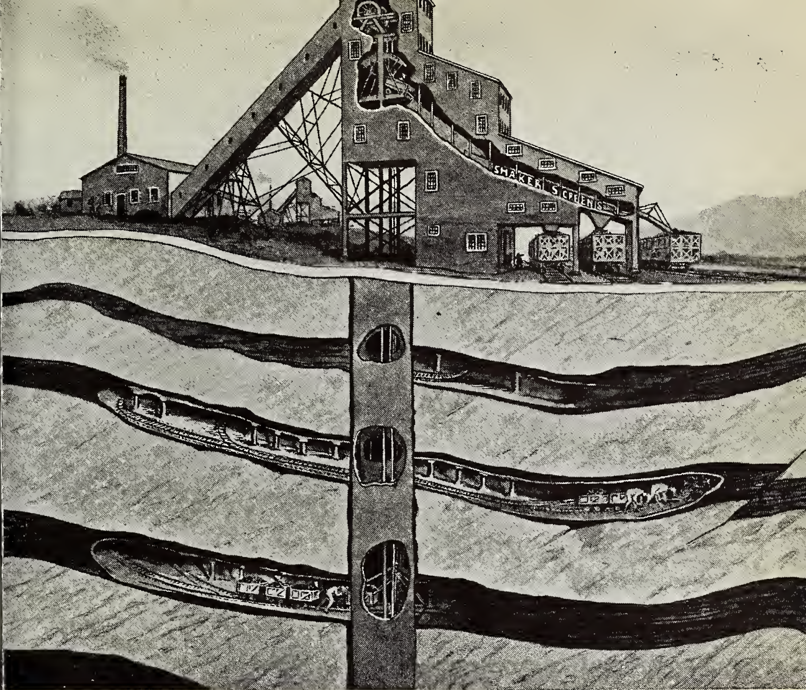
of coal is lost in mining. Some is left in a mine because it is hard to get out and would cost so much to mine it. When the mine is no longer used, it may cave in or become flooded. Then it is impossible to get out the coal that has been left. This should not happen. Every bit of coal in a mine should be brought out before the mine is closed. There may come a time when people will need this coal that has been left down in the mines. They may not then be able to mine it at all. This coal could be more easily mined now while the men are down in the mines working than after the mine has become flooded.

Then much of our coal is not properly burned. A great deal of the heat from a furnace goes up the chimney. Our home furnaces and our power plants do not use coal as well as we hope they will in the future.

The problem of building furnaces and engines which make use of almost all the coal put into them is a problem of conservation. Engineers are making better furnaces and engines every year. They will be able to make better and better use of the coal put into engines and furnaces. Men who work at these problems are among our greatest helpers.

A great deal of coal is wasted in our own homes. Our home furnaces and stoves are not operated so well as they might be. If each household were careful in using coal, a great deal of coal would be conserved each year.

We are safe enough in having a large energy supply from coal. But it is also our problem to use the coal as well as we can. Coal must not be wasted if the people who live after us are to have a good energy supply.



Scientific American

This is a drawing of a coal mine. Notice that there is a layer of coal, then a layer of rock. Can you think of a reason for this?

PLANTS AS ENERGY SOURCES

Of course it is not necessary to wait until plants have turned into coal in order to use them as fuel.

Many people in the world today use wood to heat their homes. But scientists tell us that we have not nearly enough forests to supply wood as fuel for our factories, our power plants, or even all our homes and office buildings. We should use up our forests in a very short time


United States Forest Service

Much valuable wood was destroyed when this forest was burned. A great dea of forest land is burned over every year. Many of these fires are started by careless campers

even though we planted trees to take the place of the ones we cut down.

Some people have said that we might use for fuel plants that grow more quickly. Even if we used the best of these plants, sugar cane, we should not have enough room to grow this fuel.

Even though this is a hard problem, scientists are always working to see if they can make heating fuel and motor fuel from plants that grow quickly.

This, too, is real conservation. We must see to it that scientists are given a chance to work on the problem of conserving our energy resources.

WATER A GREAT SOURCE OF POWER

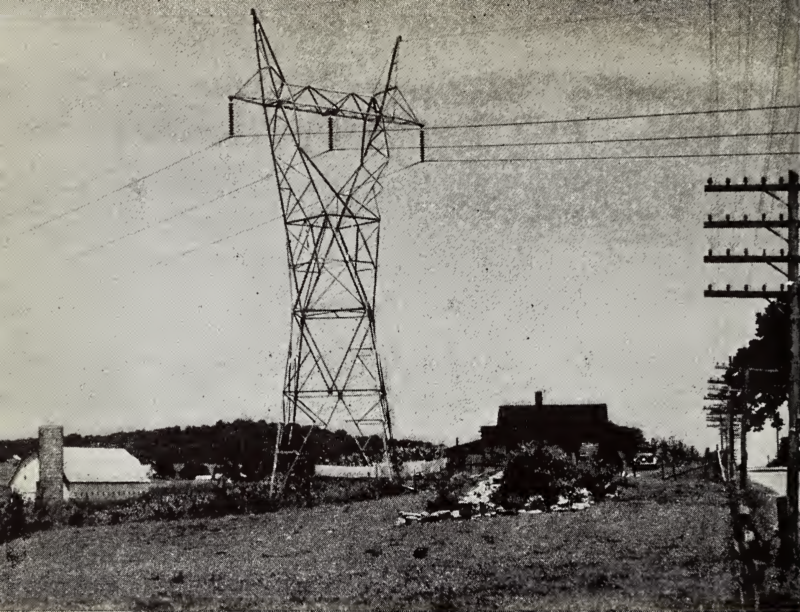
Moving water has a great deal of energy. We know that this energy can be changed to electrical energy.

Today many power plants use steam to make the wheels of the machines that make electricity move. Coal must be used to heat the water so that it will turn into steam.

Does it not seem sensible that we should use our water power to make electricity instead of using up our coal to make electricity? The trouble with this plan is that we have to build great dams to hold back the water so that the power plants can have a steady flow of water all year long. Without a dam a power plant could not be put on a river that has a great deal of water in the spring when the snow melts and very little water during the hot, dry summer.

It takes a great deal of money to build dams across rivers. Usually it would cost too much for a small group of men to build such a dam. So a city or a state or a whole nation might have to agree to build the dams. This means that the people of the country would have to spend some of their time thinking about the problem before they could decide to build a dam. But the people could help in conserving our energy resources by doing just that. Our coal and wood would last longer if we had more dams, so that we could have more electricity.

Water is a source of energy that is never used up. It turns the wheels of the machines that make electricity in the power plant. Then it flows on to the ocean.



Keystone

Wires carry electricity to all parts of the country. This farm is many miles from the power plant where water is used to make electrical energy

Some water is always evaporating from streams, lakes, rivers, and oceans. This forms clouds which are often blown back over the land. Rain falls from the clouds into the rivers, and the moving water again helps to turn the wheels of the machines which make electricity.

You see, it would be impossible to use up our water supply.

We might use electricity made by using moving water for many things, such as heating our houses, cooking our food, or running our trains. Of course we could not use

it for our automobiles, because they must be able to move over many different roads and not over a track. Some energy source, such as coal or oil or gasoline, would still have to be used to run our automobiles.

Using more and more water power might be one way to make the coal, oil, gas, and lumber resources of the world last longer.

ENERGY RESOURCES OF OIL AND GAS

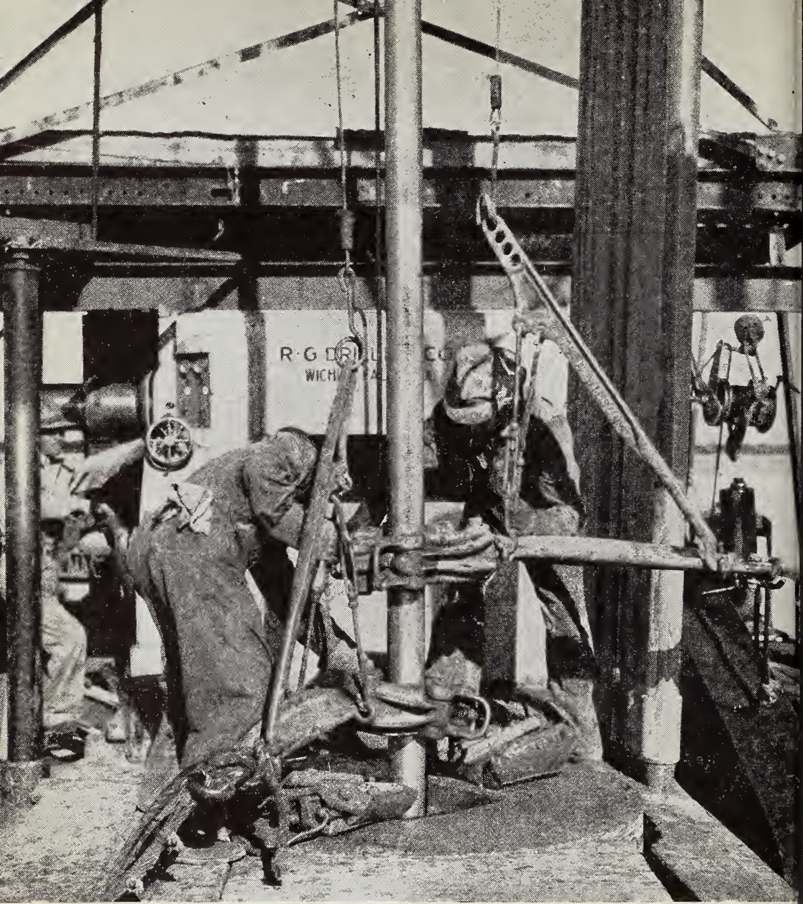
No one knows just how much oil there is in the world. New oil wells are being discovered all the time.

We use millions of barrels of oil every year. This is because oil as it comes from the ground can be made into several valuable products. It is made into gasoline, with which we run automobiles, tractors, threshing machines, and motors of all kinds.

Kerosene also comes from oil. This is used in stoves for cooking and heating as well as in lamps. Some of the oil is used as fuel oil in the furnaces which heat our homes. Kerosene is quite thin, almost like water. Fuel oil is thick, dark, and very hard to pour.

Oil is also made into special oil for motors and for greasing parts of motors. Wax for candles and paraffin for jelly glasses comes from oil.

Even though we do not know how much oil there is under the ground, we do know that we are using up our oil supply faster than we are discovering new oil wells. This means that it is quite possible that we shall run out of oil before many years.



Galloway

An oil well is a small but very deep hole. You can see the pipe which is being put into the ground. The oil will come up through this pip

The problem of conserving our oil supply is a very hard one. A great deal of oil has been wasted in the oil field. But oil men are becoming more careful about this. They pump an oil well quite dry before closing it.

It seems that about the only way of saving our oil supply is to use it more wisely. This would mean that our automobiles should be kept in very good condition, so that they will use less oil and gasoline. The problem is one that we shall all have to work out together.

Natural gas is used as fuel in many cooking and heating stoves. It is different from the gasoline which we use in automobiles. Gasoline is a liquid and is made from oil. Natural gas cannot be seen.

This gas for cooking and heating is pumped through pipes hundreds of miles long. Some gas is pumped from Oklahoma to Minnesota. It is a good fuel and is clean and easy to use.

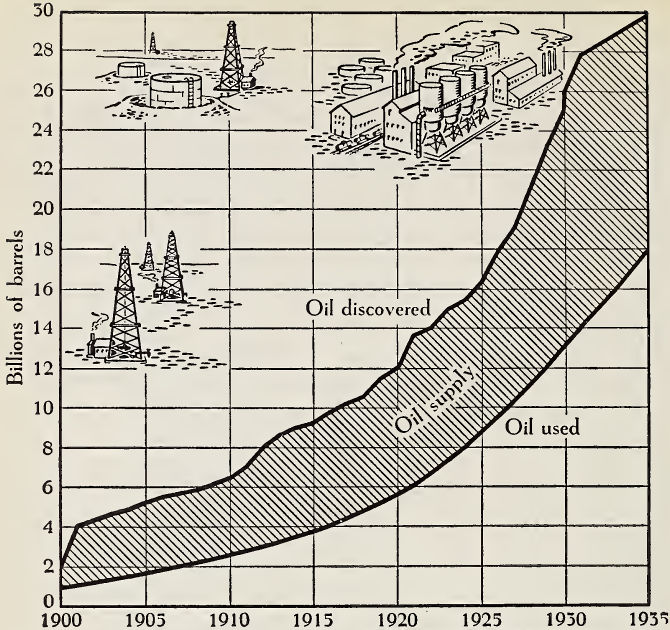
We do not know just how much natural gas there is in the earth. But the same story is true of natural gas as is true of oil. We do not discover gas as quickly as we use it. People who are able to make the best guesses say that the supply of natural gas will not last more than a hundred years.

Much gas is wasted in the gas fields. This is easy to understand when we remember that gas cannot be seen. We could be much more careful in taking care of our gas wells and pipe lines properly.

THINGS TO THINK ABOUT

1. What would your life be like if you had no coal, oil, gas, or electricity to use? Do you waste energy?

2. The softest coal is peat. The next softest is lignite. Bituminous coal is next to anthracite in hardness. Do you use any of these coals in your home?



American Association of Petroleum Geologists

This graph shows that we are using up our supply of oil very rapidly. More oil is being used, and less oil is being discovered. What will happen when the two black lines meet?

THINGS TO DO

1. Read about the discovery of oil in Pennsylvania by Colonel Drake.

2. Find out how oil is brought out of the ground today.

3. Find out how coal is mined.

4. Visit a power plant if you care to see how the energy of water or coal is changed into electrical energy.

5. Watch the newspapers for conservation news.

Conservation Is Our Business

It is easy for us to say that we are each doing the best we can to conserve our energy resources. But few of us think about conservation very often.

As you grow older, you will be faced more and more with the problem of conserving energy resources. You will need to read conservation reports carefully, think about them, and make plans with other people.

If each of us should try separately to conserve our energy resources we might not be able to do very much, but if we should think and work together on this problem we might be able to do a great deal.

THINGS TO THINK ABOUT

Ask your teacher to help you find out what the governments of your state and nation are doing to conserve our energy resources.

XI

Plants, How They Grow

LIVING THINGS

YEASTS ARE PLANTS

GREEN ALGAE

PLANTS FROM SPORES

SEED-MAKING PLANTS

PROTECTING PLANTS

AS WE look about us, we find that all things differ from each other. We see stones and soil and trees and animals. We know that some of these things do not move and grow, while others do move and grow. We soon learn that some things are alive and that others are not.

How can you tell the difference between living things and things which are not alive? Living things need food and air. Living things grow. They produce other living things like themselves. Often they can move about. Things which are not alive do not need food or air. They cannot produce others like themselves. Living things must have water to live. Often they can smell, or feel, or see. This is not true of things which are not alive.

It is very important that we know enough about how plants grow so that we shall be able to care for them. They are necessary for our lives. We not only use plants for food, but they often help us in other ways. Soil may be held in place by the roots of trees or grass. Have you seen trees being planted on the side of a hill to keep the soil from washing away?

Living Things

PLANTS AND ANIMALS DIFFER

There are many, many, different kinds of living things. Some are so small that you cannot see them without a microscope. Others are so large that they take many years to grow to their full size. But all living things can be put into one of two big groups. They are all either plants or animals.

Grass, trees, flowers, and ferns are all plants. Things like earthworms, insects, turtles, birds, dogs, and horses are animals. In some ways plants and animals are alike. In other ways they are different.

You know about many kinds of living things. You have seen them grow. You know that they need air and water. You must feed your pets or they will die. They must have energy to grow. Plants make their own food, but animals must depend on plants for the food which gives them energy.

Animals and plants are different in many ways. Most of the plants around us stay in the same place in which they first started to grow. They do not move around from one place to another. They have roots which grow in the soil. These roots furnish them with water and minerals such as iron. These materials are used in food-making. Animals cannot make their own food. They must eat plants or other animals which eat plants. This is the most important difference between plants and animals.

Plants must breathe and use food. But they do not have lungs or a stomach. Animals can often feel and see, but plants cannot. Can you think of any other differences between plants and animals?

PLANTS AND ANIMALS ARE ALIKE

In one important way, however, all living things are alike. No matter whether it is a moss plant, or a tree, or an elephant, or a fish, all living things are made up of a substance called protoplasm. Human beings too are made up of protoplasm. Protoplasm is a colorless material, somewhat like the white of a raw egg. It is not the material which gives a living thing its color, but it is the material of which all living things are made.

Protoplasm is not the same in all living things. It is slightly different in each kind of plant or animal.

Perhaps you are wondering why animals and plants appear as they do if they are made up of protoplasm. This is because it is not just a mass of material, but it is put together in very small parts called cells. Cells are tiny packages of protoplasm with a certain size and shape. Every living thing, both plant and animal, is made up of packages of protoplasm. You would be right if you said that living things are made of cells.

Some plants and animals are so tiny that they are made up of only one cell. Large plants and animals are made up of many millions of cells. So even though all living things are made up of protoplasm, they differ because of the different cells of which they are made.

Moulin

These giant Sequoia trees are the largest plants growing in the world today

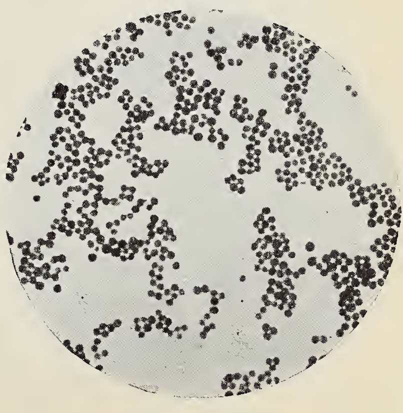
PLANTS DIFFER

There are many more kinds of plants than any one person can know. Some of these are so small that you have never seen them. Others are very large. The Sequoia trees found in California are among the largest plants ever known in the history of the world. They grow to be very, very, old. Some which have been cut down have been thought to be four thousand years old.

Most of the plants that you know about are alike in one way. They are all green. But do you know that many kinds of plants are not green? Mushrooms, for example, are not green plants. Many kinds of seaweeds may be brown or red in color.

The plants that you know best are green because in their leaves is a green substance called chlorophyll. This chlorophyll is very important to the plant. Even though a plant had plenty of water, carbon dioxide, and light, it could not make food without chlorophyll. Just how chlorophyll helps with food-making, no one knows. But we do know that without light energy and chlorophyll, other materials cannot be made into food by the plant.

This picture of bacteria taken through a microscope shows some of the smallest plants in the world today



Not all plants, however, need light energy. Those that have no chlorophyll in their cells usually grow best where there is little or no light. Since these plants have no chlorophyll, they cannot make their own food. They depend on other living things for their food.

THINGS TO THINK ABOUT

1. Food-making in a plant is called by a special name, *photosynthesis*. This comes from two Greek words that mean "light" and "putting together." So photosynthesis means putting together in the light. Do you know what a plant puts together in the light?

2. In some cities it is very difficult for food to be made by plants. Smoke, dust, and soot settle on the leaves of the plants. A great deal of light energy is shut out from the leaves because of this.

THINGS TO DO

This experiment will help you to see how the parts of a plant grow.

Put several beans on wet blotting paper. Cover them with another piece of moist blotting paper. Then put them in a dish. Always keep the blotting paper moist.

When the root of a bean is about one inch long, mark it off into small equal parts. Use pen and India ink for this. Return the bean to the moist blotters in the dish. After a couple of days look at the root. Where has it grown?

The bean seed will become soft as the young bean plant uses the food stored in the bean. When this happens, plant the seed in good soil. Keep it watered and let it have plenty of sunlight.

Mark the stem in the same way that you marked the root. Where does the stem grow?

Yeasts Are Plants

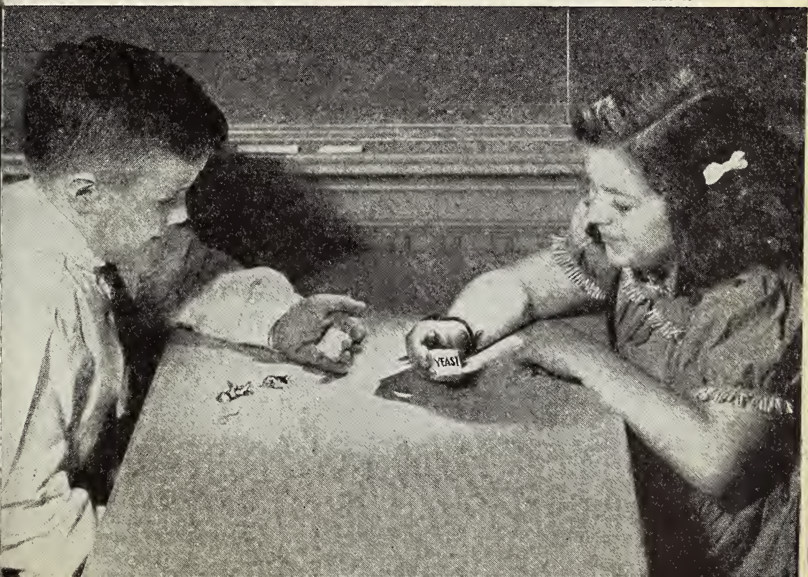
WHERE DO YEASTS GET FOOD?

You may have watched your mother or a baker making bread. The flour and milk and other things were mixed to make the dough. Usually a cake of yeast was used in the dough. You may have been told that the yeast made the dough "rise." The yeast kept the bread from being soggy and heavy.

A cake of fresh yeast is an interesting thing. To you it does not look like very much of anything. You would not think that it is made up of many, many living plants. Yet that is the exact truth. Each cake is made up of millions of living plants.

The boy in this picture is holding hundreds of tiny living plants in his hand

Richie



Each of these plants is made up of only one cell. Yeasts do not have chlorophyll; so you would not expect them to make their own food. They use food, but they do not make food.

When your mother mixes yeast into her bread dough, the tiny one-celled plants will use the sugar in the dough for food. As they do this, a real chemical change takes place. The sugar in the dough is changed by the yeast plants. Carbon dioxide and alcohol are formed.

When the dough is put into the hot oven, the heat causes the alcohol to evaporate. The carbon dioxide is also driven out. That is why bread is full of tiny holes.

So yeast plants are used in making bread because they cause a chemical change as they use the sugar in the dough for food. If yeasts made their own food, this chemical change probably would not happen.

YEASTS GROW

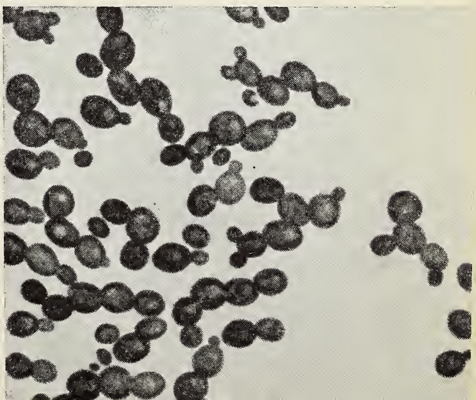
Even though each plant is only one cell, yeasts can grow. If the plants have plenty of food and are kept in a warm place, they grow very rapidly. If you could watch the growth of a yeast plant under a microscope, you would see an interesting thing. First of all, the tiny yeast plant would grow to be a little larger. Then when it reached its full size, a strange thing would take place. The cell would slowly begin to divide into two cells. Where there was only one cell before, there would be two cells now. Each of these cells would be very much like the other.

Suppose you had time to watch the yeast plant further. You would see that each of these two cells would grow to full size. If there were still enough food, moisture, and warmth, each of the two cells would divide again. In a few hours you would have four cells where there had been only one. As long as conditions were good, this would happen many times. After a while you would have thousands of yeast cells. Each plant would be much like every other plant. You would see that by dividing in this way the yeast plants would form a chain of cells. But each of these cells is a plant by itself. A chain of cells would be a whole chain of separate plants. A tree is made up of many chains of cells, but each tree cell depends on another tree cell.

So a chain of cells may be a chain of single plants, or a chain of cells may be a part of a larger plant.

Yeast plants are all about us. If you put some fruit juice in an open dish, it will soon begin to change. It will probably turn sour if you let it stand long enough. This happens because yeasts which are in the air get into the fruit juice. They cannot make food; so they use sugar in the fruit juice for food. There are many wild yeast plants in the air.

These yeasts have been growing for only three hours. Notice how chains of cells have been formed from one cell



THINGS TO THINK ABOUT

1. Do you know any plants other than yeasts that cannot make food? Molds are plants which cannot make their own food.

2. What do you suppose would happen if all plants had to get food the same way that yeasts do?

THINGS TO DO

Should you like to see what happens when yeast plants use sugar for food? Put a little water into a small bottle. Dissolve as much sugar as you can in the water.

Now put in a piece of fresh yeast that is about the size of the eraser on the end of a pencil. Put the bottle in a warm place.

In a few minutes you will see bubbles of gas escaping from the liquid in the bottle. These are bubbles of carbon dioxide. The yeast plants are causing a chemical change as they use the sugar for food.

Green Algae

WHAT ARE ALGAE?

So far you have been reading about one-celled plants which do not have chlorophyll in them. There are many kinds of one-celled plants, however, which do have chlorophyll. They are green in color and can make their own food. Some of these are very common. You can easily find them and study them. These green one-celled plants are called algae.

At some time you have learned that Indians lived in our country before Europeans settled here. They lived in wigwams and were good hunters. They traveled long distances through the forests, and they did not often lose their way. Some books say that they could find their direction by looking at the moss on trees. Moss was supposed to have grown only on the north side of the tree, since it likes to live in the shade. The story says that an Indian would look at a tree and find on which side the moss grew. He could then tell in which direction north was, and so he could find his way.

This story is not quite true. The Indian might have been able to find his way easily, but the green growth did not always help him. The green growth found on the bark of a tree was not always moss. Nor was it always found on the north side. Sometimes the shaded part of the tree trunk faced another direction.

If you will go to a woods and look at the trunk of a beech tree, you will probably find a green plant growing

on it. This is very small, and looks like a thin, green coat. If you can take a small piece of the green coat with you, look at it through a microscope. You will see then that the green part of the bark is not moss. You will see that this is a tiny, one-celled plant. Each plant is round and contains green chlorophyll.

Usually there are many of these green cells, so that they make up a colony, or group. But each of them is a plant by itself. Each cell makes its own food. Each breathes. Each divides into more cells like itself.

The scum floating on this pond is made up of many small green plants called algae

Rutherford Platt

Some of the colonies may be made up of six cells or more. If you find a cell which has just divided, you will see two cells together, just as you did with yeast. Yet this plant is different from yeast. It makes its own food. So it does not live on sugar.

None of the plants which we have studied so far in this story have leaves, stems, or roots. In this way they are different from the plants which grow in your garden or on your farm. In order to get water, they must be surrounded by it. That is why they grow best in wet places.

The green one-celled plants can manufacture their own food. They do this by taking in water through their cell wall. In the water there is some carbon dioxide. The water and carbon dioxide combine with each other to form sugar. The plants then use the sugar they have made as food. But they can make sugar only if chlorophyll is in the plant and if there is light. Without chlorophyll or without light energy, no sugar is made.

One-celled plants, then, grow and produce other one-celled plants like themselves. They do this by dividing into two parts, each much like the first one-celled plant. Each of these parts then divides. This goes on all the time. For this reason there are always one-celled plants on the earth wherever there is plenty of water, soil, and light.

THINGS TO THINK ABOUT

1. All algae are not green. Some of them are brown, others red. This is because they have a brown or red substance besides green chlorophyll in their cells.

Brown and red algae often live in the seas and oceans. Or they may live in ponds, lakes, and streams. You have seen or heard of seaweed. It is an alga. Sometimes seaweeds grow to be many feet in length.

2. Algae are important because they are used as food by many animals that live in the water. They are eaten by fish and young tadpoles. They give off oxygen into the water when they make food. This oxygen is used by the water animals when they breathe. Animals give off carbon dioxide when they breathe. The carbon dioxide given off by fish and other water animals is used by the algae to help in making sugar.

THINGS TO DO

Other green algae look quite different from the kind that grows on beech trees. If there is a pond or stream near your home, visit it after school. In the pond or stream you will probably see a green scum. Some boys and girls call this "pond scum" or "frog's spit." You will be surprised to learn that pond scum is really a very beautiful plant if you look at it through a microscope. Bring some of it to school in a small bottle of water.

As you look at this plant, you will notice first of all that it is made up of very thin green strands. When you took the pond scum out of the water, you noticed that it felt rather slimy. Each of the thin strands is covered with a very thin layer of a substance that is very much like gelatin. If you will take one strand and hold it in the air for a moment, it may curl up.

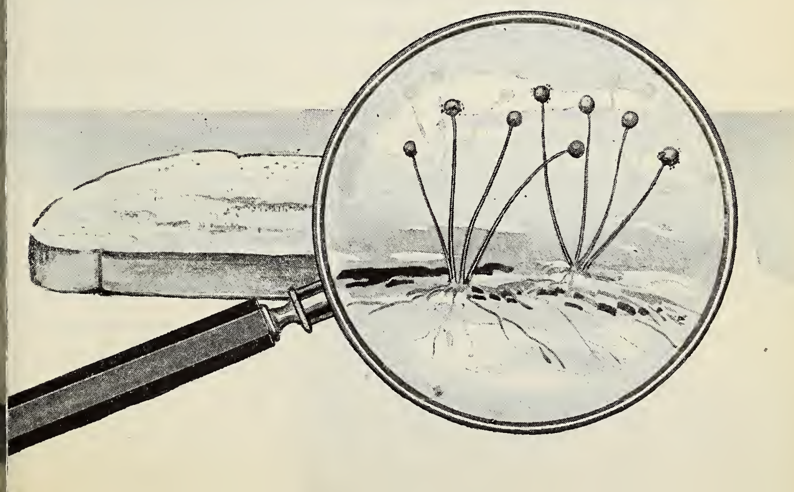
As you study one of these strands under the microscope, you will see that it is really made up of long cells. There are divisions between the cells. Each cell contains chlorophyll, which you will easily recognize by its green color. Each cell is a separate plant.

Plants from Spores

So far we have been talking about one-celled plants. Many kinds of plants, however, are made up of many cells. These many-celled plants are quite common and well-known to all of us. The plants in our flower and vegetable gardens are many-celled plants. Trees are many-celled plants. Can you name other many-celled plants?

Some many-celled plants have chlorophyll and others do not have it. Mushrooms and molds are many-celled plants which do not contain chlorophyll. You remember that plants without chlorophyll cannot make their own food. That is why molds live on bread and other things. Since they cannot make their own food they live on ready-made food.

Bread mold looks like this when you look at it through a magnifying glass



Perhaps if you look in your pantry at home you may be able to find a piece of moldy bread. If you cannot find a piece of bread that is already moldy, you can make one. Take a piece of fresh bread and put it under a glass jar. Keep the piece of bread damp. In a few days you will notice that mold is forming on it. Where did this mold come from?

The cells in the mold plant usually divide into two cells, so that the mold grows larger. But some cells in the mold plant grow into small, upright branches. On the end of some of these upright branches little black dots appear. Within these little black dots are formed certain special cells called spores. These spores grow and ripen. When the little black dots burst open, the spores are so light that they are blown about in the air.

Air currents carry the spores about until they fall. Some spores fall into a place where there is moisture, warmth, and food. Then they begin to grow. They do not need sunlight, since they do not need light energy for food-making. Soon other mold plants may be seen. These again produce spores, which are carried about by the wind. In this way molds are spread around and may be found everywhere in the air.

Have you ever seen the spores that drop from the underside of mushrooms?

McFarland

You read about the way yeasts produced more of their own kind when the cells divided. But molds may produce other molds by means of special cells called spores. These can grow into a new mold plant.

Have you ever seen spores? Perhaps you live on a farm. Have you noticed masses of a black, powdery substance which sometimes grows on the stems of corn plants which have been injured? You probably have heard your father or brother call this smut.

Smut, too, is a plant. It is often dark gray or black in color. It has no chlorophyll in its cells. When the corn plant is injured, some of the sap in the plant comes to the surface. A smut spore may be blown into the injured place. The spore begins to grow. It feeds on the sap of the corn plant.

When it is fully grown, it produces millions of spores. Perhaps you have kicked at this smut when it was dry. You noticed that a small cloud of black dust appeared. This black dust was made up of millions of very tiny, black spores. Each of these will grow into a new smut plant if it is carried by the wind to a place where everything is just right for it to grow.

THINGS TO THINK ABOUT

Have you ever gone for a walk through the woods? Perhaps you have seen puffballs there. Puffballs are a kind of mushroom. Some of them are not much larger than a small ball. But sometimes they grow so large that one of them will fill a pail. Many people eat puffballs. Puffballs are different from mushrooms in some ways. They do not grow on stalks, but grow close to the ground.

If you can find a dry puffball, break it open. Inside you will find a brownish powder. This powder is very light and is easily carried by the wind. It is made up of millions of spores. These spores will grow into puffballs if they are carried to a damp, shaded spot where the earth is rich.

What do you think would happen if *all* the spores from mushrooms and mold were to grow into new plants? Why do not all the spores grow into new plants?

THINGS TO DO

Ferns produce spores, but they are different from mushrooms and molds because they have chlorophyll. Ferns make their own food. They are different from the green plants which we know best because they produce spores. You have never seen a real fern bloom, because ferns do not have blooms.

If you look on the lower side of fern leaves you will sometimes find a number of little brown spots. These little brown spots are spore cases. Spore cases are made up of cells which can produce spores. The spores of a fern are very much like the spores of a mushroom, of mold, or of smut.

Try to find a fern leaf which has spore cases on it. Tap the leaf to make the spores fall on a sheet of clean white paper as you did with the mushrooms. If you are able to get some spores, look at them under a microscope. What do they look like?

Seed-making Plants

FLOWERING PLANTS

So far, some of the many-celled plants you have read about have no chlorophyll, no roots, and no leaves, and they are not green in color. Now let us think more about some green many-celled plants. You will find that in many ways they are quite like the plants you have already read about. In many ways they are very different.

The plants you will read about now are different from those you have studied in this way: they produce seeds. There are many thousands of kinds of seed-producing plants. They include trees, grasses, vegetables, and plants grown for their beautiful flowers.

The flowering plants have well-developed roots. They have green leaves. Because these green leaves contain chlorophyll, they are able, with the help of light energy, to make their own food from water and carbon dioxide.

How many different kinds of flowering plants can you name? If you should start to make a list of them, remember this: Many kinds of plants have flowers so unusual that you probably do not think of them as flowers. Wheat plants have flowers. Can you describe a wheat flower? Many grasses have flowers, though you may have never noticed them. Have you ever seen the flowers of a maple tree? What does the flower of a cabbage plant look like? Do corn plants have flowers?

Roberts

Flour is made from the seeds of wheat. Where are the seeds of wheat?

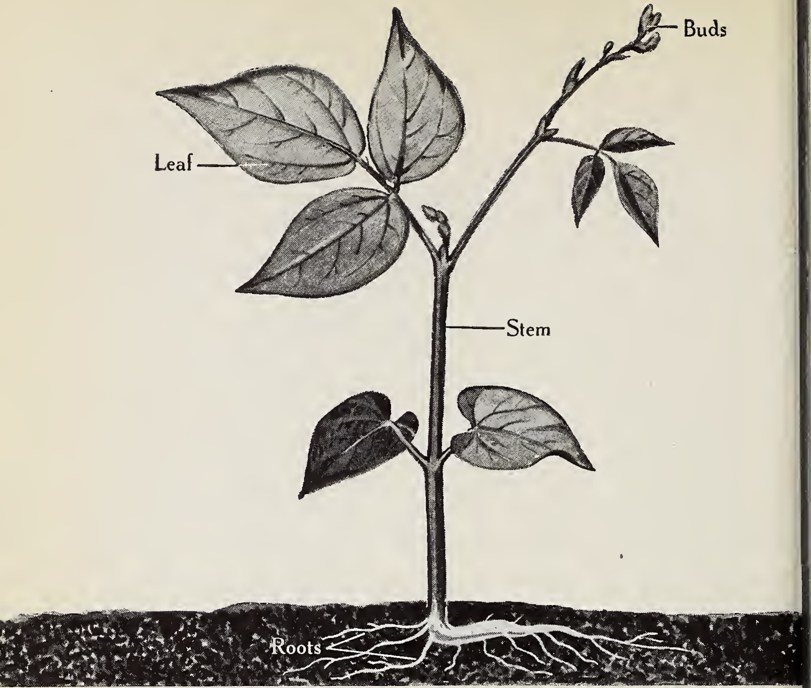
Plants which produce flowers also produce seeds. There are so many different kinds that you cannot possibly know or name them all. Some of them are very necessary to us. Others are grown only for their beauty. Still others crowd out the useful plants in our gardens. We call these weeds. We pull weeds out to make more

room for our garden plants. Still other flowering plants are poisonous to the human skin, as you know if you have ever suffered from poison ivy. The pollen of certain plants causes some people to suffer from hay fever. Some plants produce nectar, from which bees make honey. Many of our most useful medicines are made from plants.

Perhaps some of the most useful plants are those which belong in the grass family. Corn belongs to the grass family. So do wheat, barley, rice, rye, timothy, and sugar cane. Rice, a flowering plant, is the principal food of nearly half the people in the world. Wheat and corn are very important crops in North America and Europe. They are used as food both for man and for domesticated animals which man raises. Sugar cane, which is somewhat like corn, is the principal source of the world's sugar.

The lily family of plants is one of the most interesting groups. In this family belong such plants as tulips, hyacinths, Easter lilies, and tiger lilies. Many food plants too belong to this group, including onion and asparagus plants. The onion and asparagus are very different from the tulip and hyacinth; but they all belong to the same group of plants.

Roses belong to another large group of plants. They are in the same family with apple trees, raspberries, blackberries, and hawthorns. These different plants may not look very much alike to you. But the scientist who studies them knows that in some ways they are very much alike; so he puts them into the same family.



Could you tell about the work of each part of a plant?

Flowering plants, then, are very important to us. They supply a great part of our food. Because all flowering plants cannot grow well in all parts of the world, we must raise certain plants in one part of the world and send them to other parts to be used for food. This is why it is so necessary that we all work together to see that all parts of the world have the right kinds of food and enough of them.

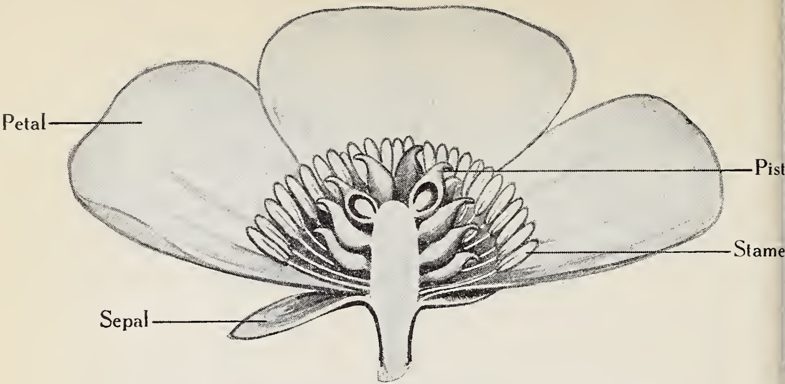
FLOWERING PLANTS COME FROM FLOWERING PLANTS

Every living thing, including yourself, has ancestors. These ancestors also had ancestors. And so the line goes far back in the history of the earth. All living things come from living things. Living things cannot come from things which are not alive. Many years ago people believed that some forms of life arose from decaying animals. Today we know this is not true.

Flowering plants produce other flowering plants. Let us see how this happens.

All of you have seen flowering plants. In the early spring you have picked violets in the woods. You have seen tulips blooming. Roses, as you know, are famous for their beauty and perfume. You have seen apple trees blossoming in the spring. Peaches blossom even before the leaves come out of their buds. Tomatoes have a yellow blossom. So do cucumbers and pumpkins and squashes. Clover blooms are a common sight almost everywhere. The purple or white blooms of lilac bushes are lovely.

In many cases fruit develops where the blossom appeared in the spring. Cherry blossoms fall to the ground. The white petals look like snow. Later you pick ripe cherries from the tree. Apple trees, peaches, and many other fruits are like that. Sometimes a flowering plant produces no fruit, only seeds. But almost always you will find seeds in the fruit.



Do you know what each of these parts of a flower does?

Let us look at a flower. Select a large one, so that you can see the parts used in seed-making. If you can get a primrose, you will find it easy to study. If you cannot get a primrose, try some other large flower.

Notice that the flower, in many cases, seems to be set in a green cup made up of sepals.

Then notice the beautiful colored petals. Are there many petals, or only a few? What color are they?

Now look inside the flower. What do you see there? If you have the right kind of flower, you will see several things inside the cup of your flower. In the center you will find the pistil of the flower. Around the pistil you may see several stamens. The stamens and pistil are the most important parts of the flower.

Look at a stamen through a reading or magnifying glass. Does it have a knob at the end? In this knob, called the anther, are produced many little grains of pollen. In the pollen grains are the sperm cells, which you will read about later.

Pull the pistil out of the flower. Cut through the pistil. Do you notice that the pistil leads downward to a thicker part of the stem? In this thickened part at the bottom of the pistil are the egg cells. New seeds will be made in this part of the flower.

Some plants do not have flowers with stamens and pistils in the same flower. Sometimes the stamens are in one flower and the pistils are in another.

In flowering plants the wind carries the pollen from the stamen to the pistil. When a pollen grain falls on a pistil, the pollen grain begins to grow. It grows a long, thin tube through the pistil to the thick part at the bottom. When it reaches this part of the pistil, the sperm cell in the pollen grain unites, or joins, with one of the egg cells. This is called fertilization.

After the egg cell has been fertilized, it begins to divide. It divides many times until a baby plant is formed. This baby plant, together with the food stored around it, is the seed.

Sometimes the pollen from the stamen does not get to the pistil. When this happens, no seed is formed. Some flowers which have no stamens must get their pollen from other plants like themselves which do have stamens. The pollen may be brought to them by the wind or by insects.

All of you have seen bees. You know that they will get honey from flowers. Flowers produce a sweet liquid at the base of the pistil. Bees gather this liquid, which is called nectar, and make honey from it. They store the honey in their honeycombs.

Perhaps you have seen a bee gathering nectar. You may have noticed that the bee is covered with a yellowish powder. This yellowish powder is made up of pollen grains which stick to the hair on the body of the bee. The bee carries these pollen grains from one flower to another. As the bee enters the flower, some of the pollen grains are brushed off by accident on the pistil.

If the pollen grains are the right kind, they will start to grow a long tube down through the pistil. Then they will fertilize the egg cells there. Bees carry pollen from one flower to another. So they help to produce seeds.

EVERGREENS GROW FROM SEEDS

Some trees do not have flowers. Evergreen trees, such as the pine, fir, and spruce trees are in this group. They are called evergreen trees because there are always green leaves on the tree. Perhaps you will say that pine trees do not have leaves. You will say that they have needles, but needles are a special kind of leaf. They may stay on the tree from three to ten years.

Pine trees have cones instead of flowers. Each pine tree has two kinds of cones. One kind of cone produces sperm cells, which are in the pollen grains. The other kind of cone produces egg cells.

The cones which produce sperms appear in the spring of the year. Growing in the cones are stamens, which produce the pollen. Late in the spring the pollen is scattered by the wind. It looks like a yellowish powder. But we know that it is made up of tiny, living sperm cells.

The wind carries the pollen about. Some of it may fall on the kind of cone which produces egg cells. Then it grows a long pollen tube down to the egg cell and unites with it.

The fertilized egg does not grow into a new pine tree, however. Instead, it develops into a pine seed. These pine seeds have very small and delicate wings. When they ripen, they are carried away by the wind. When they settle down on the ground they may develop into new pine trees.

So a pine tree can produce others of its kind only if its pollen unites with an egg cell to produce a seed.

If the ground is warm and damp, the tiny plant within the seed may begin to grow larger. Its cells make more and more cells. Some of them make up the roots ; others become the stem, and still others leaves. Finally, the roots are quite able to furnish the young pine with water and minerals from the soil. Then it begins to make its own food with the help of light energy. Until that time, the young pine tree depends upon the food stored in the seed to keep it alive.

ALL FLOWERING PLANTS ARE NOT GROWN FROM SEEDS

A great many plants do not produce seeds even though they may have large, beautiful flowers. Roses do not produce seeds very often. Strawberries would be very hard to grow from seeds. Tulips are not grown from seeds, but from bulbs. Farmers do not plant potato

Richie

Geranium plants may be grown from slips. You would not plant seeds if you wished to grow a geranium

seeds. They plant potatoes like the ones you eat, except that instead of planting whole potatoes they cut them into pieces, each piece having an "eye," or bud, and plant the pieces. You would not think of planting blackberry seeds or raspberry seeds if you wanted to grow those fruits. Why is this so?

Many plants have other ways of reproducing than by seeds. Suppose you want to grow some new grapevines. You do this by taking cuttings from grapevine shoots and burying them partly in soil in a flowerpot until the roots grow. Then you plant them outdoors, and they will grow into large grapevines in a few years. This is a much easier way than growing them from seed.

Raspberry and blackberry bushes grow to be quite tall. If you have a blackberry bush in your garden, you can turn the top of one of the branches down, cover it with soil, and a new raspberry bush will grow from this buried tip of the old plant.

If you have a geranium plant in your schoolroom or at home, you may try this experiment. Ask your teacher to show you how to cut a "slip" from the plant. Fill a flowerpot with rich, moist earth. Plant the "slip" in it. Be sure that the soil is packed firmly around the new plant. Water it each day, so that the soil will not become too dry. In a few days your plant will develop roots and begin to grow. This is another way in which new plants are produced without seeds.

Have you ever seen young strawberry plants growing? Strawberry plants are set out in rows or in hills. Soon each plant extends long runners in all directions. On these runners are small leaves. Roots develop below these small leaves. If the soil is soft, the roots grow into the ground, and a new plant is started. Soon the runner dries up and dies. While the new plant is very young, it receives some food from the old plant. When the new plant is able to take care of itself, it no longer needs

this food from its parent. Thus it has no further use for the runner.

Plants, then, can be grown from seeds, from cuttings, and from runners; they can also be grown from underground stems and from bulbs. All these ways of producing new plants like their parents are important to us.

THINGS TO THINK ABOUT

1. Many farmers who have large orchards keep many hives of bees in them. When the fruit trees blossom in the warm, spring days, the bees gather nectar. By carrying pollen grains from one blossom to another, they help to fertilize many of them. So the farmer's fruit crop becomes larger than it might have been.

2. Would all the plants disappear from the earth if there were no animals? Would all the animals disappear from the earth if there were no plants?

Young strawberry plants grow from runners which are put out by larger plants

THINGS TO DO

1. Cut through a bean seed. Do you see the tiny plant at one end of the seed? All the other material in the seed is food for the young plant.

2. Perhaps you would like to grow potato plants in your classroom. Here you will have an example of a plant that does not grow from a seed. Select a white potato that has large "eyes," or buds. Cut it in pieces with one "eye" to each piece. Plant the pieces in flowerpots so that they are about two inches below the surface of the soil. Water often to keep the soil damp. In a week or ten days the young potato plants will come through the soil. If you keep them in a warm, light place, they will grow quite rapidly.

After they have been growing about two weeks, carefully take the plants out of the flowerpots and find the pieces of potato you planted. From what part of the potato did the new plants grow? What has happened to the potato itself?

Nesmith

The hillside on this side of the fruit trees is not protected by trees.
Notice how badly the land has been worn away

Protecting Plants

SMALL FLOWERING PLANTS

We are beginning to understand more and more that we must protect many of our plants. Your state probably has laws which keep people from picking some of the small wild flowering plants. Some of our loveliest flowering plants are found less and less often because too many of the flowers which produce seeds are being picked. Do you know which flowering plants in your state are protected by law?

WHAT FORESTS DO FOR US

Did you ever look carefully at the soil in a woods or forest? Did you ever feel of it? It is almost always spongy, moist, and black. It is called humus.

Humus is mostly, but not entirely, decayed vegetable matter. It is often used by growing plants. Trees are very important in helping to make humus. Some of the best farm lands in the world have soil which was once humus.

Forests are also important in another way. A hillside on which trees are growing cannot be washed away by rain as quickly as a bare hillside can be washed away. The roots of trees, grass, and other plants help to hold the small particles of soil together and keep it from slipping away.

When forests are destroyed, the soil usually washes away. The soft, spongy humus disappears. There are

A forest fire can destroy in one day plants
which have been growing for many year

no tree roots and nothing to absorb the moisture. So the water passes off quickly and causes streams to overflow their banks. Floods do a great deal of damage. Villages,

towns, crops, and all kinds of living things are often destroyed. When the rains are over, the streams again become small and shallow, and sometimes dry up.

Rain or snow which falls in a forest soaks into the soft, spongy soil and is absorbed into the ground very, very slowly. It may appear later as a cool, clear spring. Many such little springs form the rivers which begin in the forest. These rivers seldom have bad floods. Neither do they dry up in summer.

Here are some of the things which all of us must do if we are to keep our forests.

Plant new trees when the old ones have been cut down.

Cut out a certain number of trees so that others can grow well.

Do not cut trees carelessly.

Destroy insect pests among trees.

Be most careful about building fires near trees.

THINGS TO THINK ABOUT

Here are some "if's" to think about.

If most or all the flowers are picked, where will seeds for new plants be found?

If plants are pulled up by the roots and thrown away, what will happen?

If we want to continue to decorate our homes at Christmas time with evergreens, what must we do?

If we see flowers in the woods and fields and along the roadsides and let them stay there and grow, what will happen?

If no plants are made to grow on steep hillsides, what will happen?

XII

Animals, How They Grow

PLANTS AND ANIMALS

ONE-CELLED ANIMALS

SEA AND SOIL ANIMALS

COLD-BLOODED ANIMALS

WARM-BLOODED ANIMALS

IN MANY ways, plants and animals are alike. In many more ways they are different. You may be surprised to know that some animals produce others like themselves in the same way as some plants do. You may even find that some living things which you did not think were animals really are. You remember that all living things are either plants or animals. Earthworms, insects, birds, and fish are all living things. They are not plants. So they must be animals.

Man has learned to use animals as well as plants. Animals do some of our work for us. They furnish us with wool, furs, silk, and leather for clothing. We eat their flesh. Milk is an important food which we get from cows and goats.

Some animals are very destructive. Certain insects eat our crops and our clothing, and some make our fruits wormy. Many of them carry diseases.

Animals live in many different places. Some animals can fly in the air. Others live in the soil. Many kinds live in the water all their lives. Animals, like plants, may be found everywhere. If you have ever had an aquarium you know that plants give off oxygen into the water. Fish need the oxygen to breath. Perhaps you can think of other ways that animals depend on plants.

Plants and Animals

Animals are more interesting than plants to some people. Most of them are able to move about. Many can see, smell, and hear. If you have a pet at home, you know that you can teach it to do many things. At circuses you may have seen trained lions and tigers do wonderful tricks.

There are thousands of different kinds of animals. Some of them are huge in size. One kind of whale, which lives in the oceans, is much bigger than any elephant you have ever seen. Other animals are so small that you cannot see them without a microscope. In between these sizes you will find many other animals.

You have no doubt seen very small tadpoles which grow into frogs two or three inches long. You have seen dogs so small that they fit easily into a shoe box. Others are so large that they may weigh a hundred pounds or more. You have seen ponies that are not so tall as you are. On the other hand, there are horses so large that they weigh a ton. An elephant may weigh many tons. Animals are of many sizes and shapes.

In one way all animals, like all plants, are alike. They are all made up of protoplasm. The protoplasm in animals is organized into cells, just as it is in plants. Of course the protoplasm of animals is a little different from that in plants. It is different in each kind of animal, too. But it is still protoplasm.

Animals are different from plants, however, in that there is no chlorophyll in any animal cell. This means

that the animal cell cannot make its own food from carbon dioxide and water with the help of light energy. For that reason most animals must seek food. Many of them move around to do this. All animals eat other animals or plants to keep alive. If they do not eat, they starve and die.

One-celled Animals

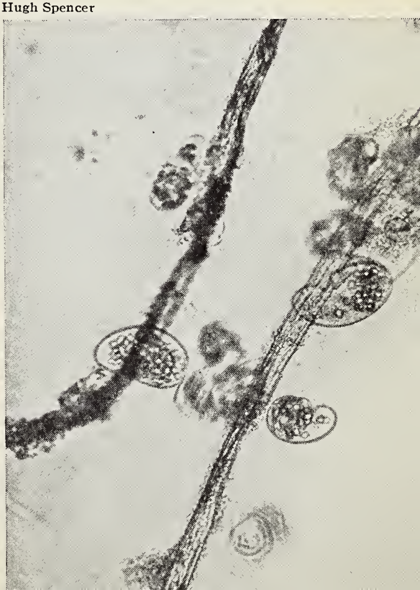
You have read about one-celled plants like yeasts and algae. You may be surprised to hear that there are many different kinds of one-celled animals too.

Like the one-celled plants, they are found almost everywhere. Some of them live in ponds and streams. Others are found in great numbers in the salt waters of seas and oceans. Some of them live in the soil. Others live in the blood of larger animals. Many kinds live in the sap of plants. Some of them live in the stomachs and intestines of animals. Some of them cause diseases.

Malaria and sleeping sickness are caused by tiny one-celled animals that find their way into the blood of people.

The oval-shaped bodies are one-celled animals. This picture was taken through a microscope

Hugh Spencer



One-celled animals also cause other diseases. Scientists have studied and named about fifteen thousand different kinds of one-celled animals. There are probably many more kinds that have not been studied.

You remember that one-celled plants can divide and produce new cells. This is their way of producing other plants like themselves. One-celled animals can do the same thing. A one-celled animal may produce many, many other one-celled animals in one day.

Many one-celled animals are very interesting. Some of these small animals eat other one-celled animals. Some of them do not like to be in bright sunlight. They move into the shade if sunlight falls on them. Some will live only in clear water. Others like water in which there is much decaying matter. Some of them live near the surface of the water, and others live near the bottom. All of them must have food and moisture. Without these they cannot grow.

THINGS TO THINK ABOUT

What a strange world this would be if no one-celled animals died for two weeks!

Can you think of the many, many one-celled animals there would be at the end of two weeks?

THINGS TO DO

Should you like to have a zoo of one-celled animals? It is not hard to have such a zoo in your classroom. All you need is a jar that will hold about a quart of water. Into the water in the jar put a small handful of hay or dried grass. Put this in a dark and warm place for a few days. Soon there will be many one-celled animals in the water.

Most of these will be so small that you will be unable to see them without a microscope. Some of them are a little larger than others. You may be able to see these. They will look like tiny specks of grayish-white matter floating in the water. Some of the hay or dried grass will be used as food by the one-celled animals.

If you have a microscope, try putting a drop of the water from your zoo on a glass slide. Cover it with a thin cover glass. Now look at it under your microscope. Are you able to see the animals? Do they move around, or do they stand still? What do they look like? Can you be sure you are not looking at one-celled plants?

Sea and Soil Animals

MANY ANIMALS LIVE IN THE SEA

There are many kinds of many-celled animals. In the sea there are great numbers of fish. Besides fish there are many animals in the ocean which you may never see alive. Sponges, for example, are many-celled animals which are found in warm seas but which you probably never see alive. The same is true of corals, whose homes are in the warm oceans, and which are also animals.

On the floor of the ocean are many queer kinds of animal life. Some of these creatures look very much like plants, and never move from one spot. Their food is brought to them by the waves. Some of them look so much like plants that they are called sea cucumbers and sea lilies.

Starfish are found in great numbers in the shallow waters near the shores. They are not really fish. Their bodies have five arms. Oyster fishermen do not like the starfish, because these creatures can open the shell of

This animal is called a sea lily.
The arms open and close

Science Service

a live oyster and eat the inside. One of the most interesting things about starfish is the way they grow new arms. If some enemy of the starfish breaks off one of its arms, a new one grows in its place.

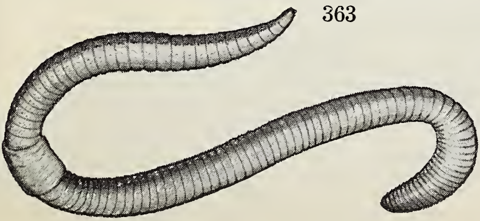
You would never have time to read about all the different kinds of sea animals. It would take you all the rest of your life to study them, because there are so many.

SOIL ANIMALS

Have you ever helped to dig up the soil for a garden? Many of you have. As you turned over the rich brown soil with your spade, you probably saw many things. Perhaps you dug up insects which ran away to hide. You may have dug up the roots of plants. And certainly you have come upon some earthworms. You have seen earthworms in the summer after a rain. They are very common animals.

You know that earthworms are good bait for fish. Many kinds of fish can be caught with them. They are important in other ways too because they make their home in the soil.

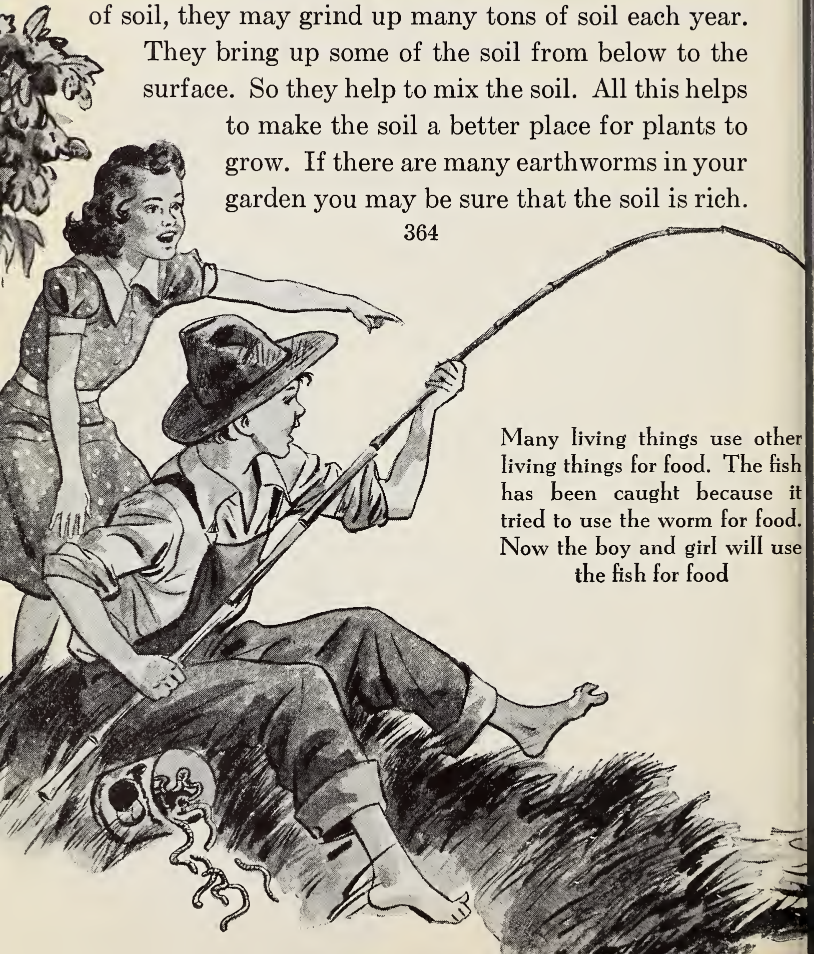
As earthworms burrow through the soil, they make places for themselves to live. Usually their nests are lined with very small pieces of leaves that are decaying. Air can enter their burrows. In this way they help to furnish air for the roots of plants.



Have you ever watched an earthworm to see how it moves?

They also eat the soil, and grind it up after they have eaten it. They do this in their gizzards where food is taken from the soil they have eaten. The ground-up soil then passes through their bodies. In this way earthworms make the soil particles finer and so help to fertilize the soil.

Since there are thousands of earthworms in an acre of soil, they may grind up many tons of soil each year. They bring up some of the soil from below to the surface. So they help to mix the soil. All this helps to make the soil a better place for plants to grow. If there are many earthworms in your garden you may be sure that the soil is rich.



Many living things use other living things for food. The fish has been caught because it tried to use the worm for food. Now the boy and girl will use the fish for food

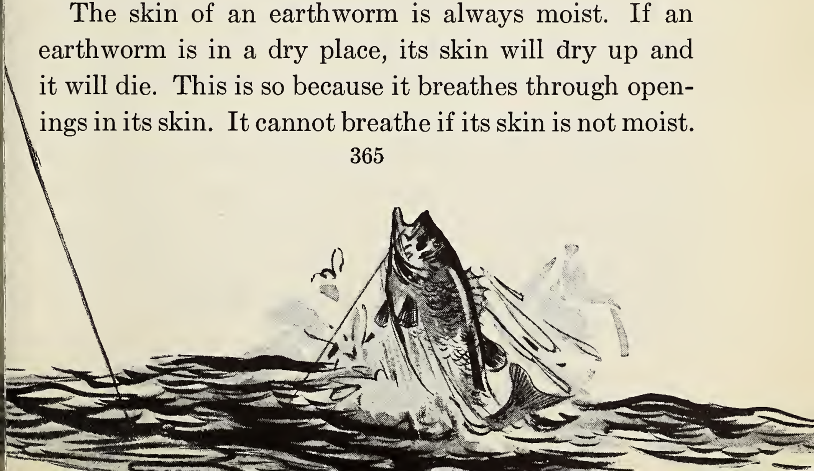
Perhaps you would like to look at an earthworm. Get a large one, if you can. Sometimes they grow to be as much as ten inches long. Notice that the body of the earthworm is made up of many rings. These rings are called segments.

How does an earthworm move? If you look, you will see rather thick hairs. They are on each segment except the first and last one. Place the earthworm on a sheet of white paper and watch it. Can you describe how it moves from one place to another?

Notice that an earthworm has no legs, no head, no neck. It is somewhat like a long tube made up of many small rings. However, you will find that it seems to move in one direction. That is, one end of its body moves forward.

At this end you will find its lip and mouth in the first segment. The food it eats is mostly decaying plant material. The food passes through the mouth into a tube that is within the body. In this tube the food is digested.

The skin of an earthworm is always moist. If an earthworm is in a dry place, its skin will dry up and it will die. This is so because it breathes through openings in its skin. It cannot breathe if its skin is not moist.



But if an earthworm is put into water, it drowns. This is because it cannot breathe in water. The water keeps the air from reaching the openings in the skin. An earthworm does not have gills like a fish. You see, an earthworm must use air just as you do even though it has no lungs.

Many kinds of earthworms do not come out of their burrows in the daytime. They stay hidden in the soil until the sun goes down. When it is dark, they may come to the surface of the ground. After a very heavy rain they may be seen in great numbers, even in the daytime. This is because the rain water has filled their burrows, and they must crawl out of them. Can you tell why?

Robins and many other birds eat earthworms and feed them to their young. Moles, those little animals that look somewhat like mice and that live under the surface of the soil, also eat them. So you see that earthworms have enemies. In spite of this there are always many more earthworms in the soil.

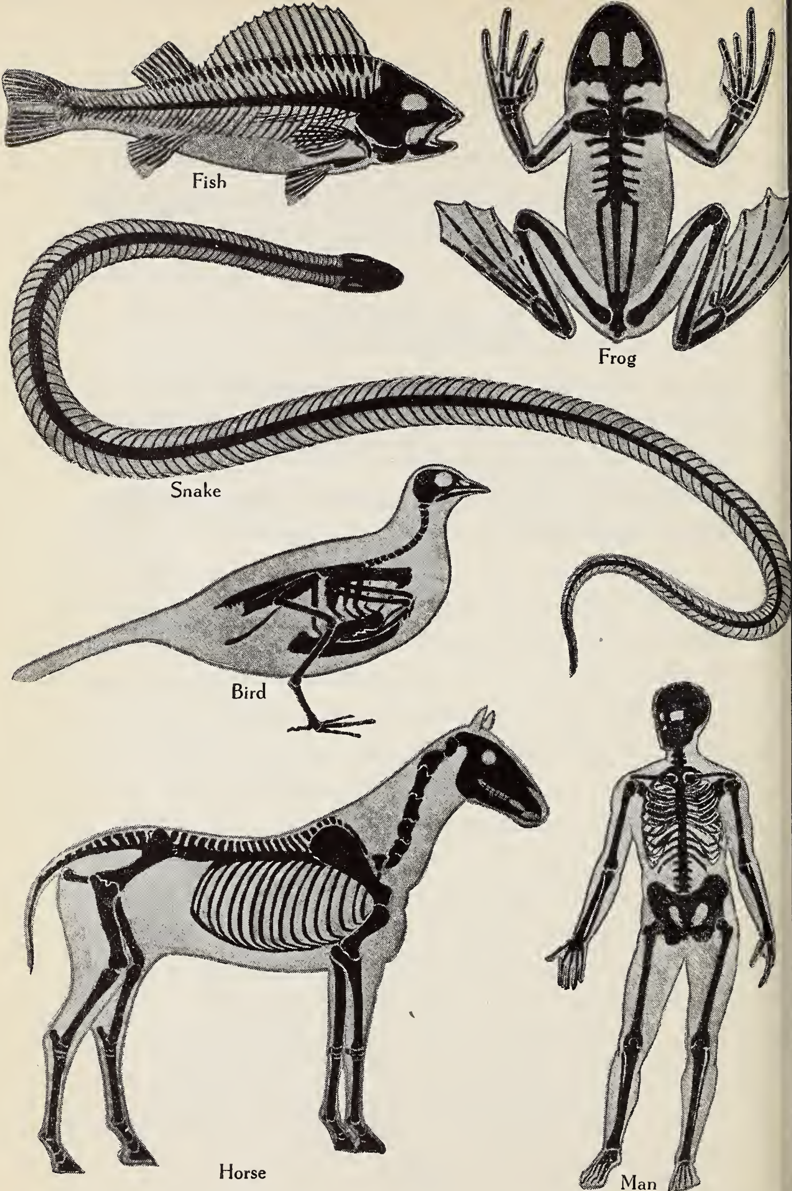
Have you ever seen very small, thin earthworms? Usually they are lighter in color than the older, larger ones. Each earthworm has in its body special cells which can produce sperms and eggs. At a certain time of the year, sperms are exchanged between two earthworms. The sperms from one will enter the body of the other through a tube. The sperms are then stored until the eggs are to be laid. As the eggs are laid, they are fertilized by uniting with these sperms.

The earthworm then leaves the eggs to hatch. The fertilized egg soon begins to divide and forms a very small earthworm. The young earthworm grows until it too is full-sized. So you see that young earthworms grow from sperms and eggs in very much the same way as the seeds of plants.

THINGS TO DO

You might like to dig up some rich soil and put it in a large jar. Watch the soil to see if you have any earthworms. If you do not, you can usually find some after a rain. Put these in your jar of dirt.

What will you have to do to make sure this is a good home for your earthworms?



Each of these animals has a backbone. Why do some animals need skeletons

Cold-blooded Animals

ANIMALS HAVE SKELETONS

Many of the animals which you know about have one important thing. They have skeletons made of bones. One-celled animals, sea lilies, and earthworms do not have skeletons. Fish, snakes, turtles, frogs, birds, rabbits, and other animals have a strong skeleton. The skeleton supports them, and makes their body stronger.

All animals are either one-celled or many-celled. Some many-celled animals have skeletons. Others do not. There are many kinds of each. Most of the animals which we see every day have skeletons.

Human beings have skeletons, as you know. You can feel the bones which make up your skeleton in your arms, legs, and other parts of your body. Your skeleton is a very important part of you. All the larger animals have skeletons made up of bones.

HOW FISH LIVE AND GROW

What do you like to do best in the spring? Boys like to play marbles, and girls like to skip rope. Many of us, however, want to go fishing. We get a can of bait, a rod, some string, and a fishhook. Then we hike to a near-by stream or lake. We bait our hook and drop it into the stream, quietly waiting for a "bite."

If it is a good day for fishing and the fish are hungry, one soon comes along and bites at the bait on our hook. At the right time we quickly pull the line out of the

water. If we are lucky, there is a fish on the hook. If it is large enough to keep, we take it off our hook and put it in a place where it cannot jump into the water again.

Fish are called cold-blooded animals. They have blood, but it is not always warm. All cold-blooded animals have usually about the same temperature as the water or air in which they live. If the air or water is cold, their blood is cold; if the air or water is warm, their blood is warm.

Our fish soon dies if we do not return it quickly to the water. It breathes oxygen, just as we do. But it cannot use the oxygen that is in the air. It must get its oxygen from the water. Oxygen dissolves in water, and then the fish can breathe it.

If you will look at a fish, you will see that it has an opening on each side of the body. These openings are just back of the head. They are called gills. The fish breathes by means of these gills. Gills cannot take oxygen from the air; they can take it only from the water.

If you have ever cleaned a fish, you may have scraped off its scales. Some fish, like eels and catfish, have a smooth skin. They do not have scales. As you eat your fish, you are careful not to swallow one of the small bones. If a fishbone should happen to stick in your throat, you would have an unpleasant time. The bones are part of the skeleton of the fish.

Fish eat many things. Some of them live on insects and other fishes that are smaller than themselves. Carp

live in muddy streams and feed on food materials in the soft mud at the bottom.

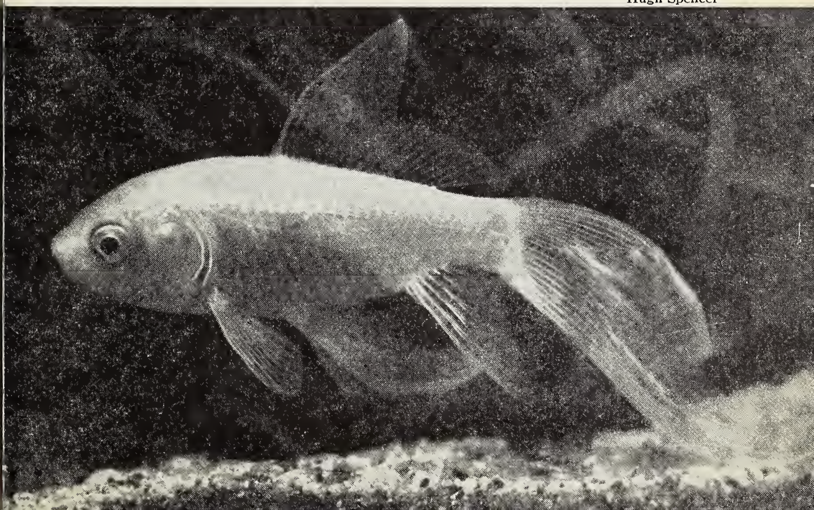
Many kinds of fish live in the oceans. Some of these feed on other fishes. Some eat the algae which grow at the surface of the sea. Some of them live many hundreds of feet below the surface of the sea. The water is always cold there. Very little sunshine, if any, reaches these fish. Some of them in the deep sea have strange shapes and habits.

When you go fishing for bass, you may catch small minnows to use for bait. Some of these may be very young fish that would have grown larger as they became older. The true minnows, however, never grow very large. They are a sort of dwarf among fishes. You will usually find them in large numbers. You seldom see one alone.

The gill slits of this fish are just behind the eyes.

Why does a fish need gill slits?

Hugh Spencer



Where did the other small fishes, which are not minnows, come from? That is an interesting story. A female fish, in the spring of the year, prepares to lay eggs. These eggs grow within her body.

Usually the eggs are laid in a place where the water is quiet, shallow, and warm. After the eggs have been laid, the male fish deposits a liquid called milt over the eggs. The milt is full of many sperms. If these sperm cells come in contact with the egg cells, they unite with them. Only one sperm can unite with one egg. As you know, we say that the egg has then been fertilized.

Perhaps you know what happens after the egg has been fertilized. It begins to divide. First the egg cell divides into two cells. These remain together. Another division takes place, making four cells in all. Soon there are eight, then sixteen, then thirty-two. Each cell divides and redivides.

In a short time a small, hollow ball of cells is formed. This hollow ball of cells begins to change in shape until it is quite long. Some of the cells become the brain of the fish. Others develop into the heart. Some go to make up the gills and the muscles. Soon the young fish looks very much like its parents, except that it is much smaller.

Most kinds of fish produce their young in this way. A few do not. Have you an aquarium in your classroom? If you have, perhaps you have a small kind of fish called the guppy in it. Guppies are fun to watch and keep. They never grow very large. They are different from the fish in the brook or lake. The female

guppy has ovaries in her body, like other fishes. These ovaries produce egg cells. But the eggs are fertilized within the body of the female and remain there for some time. The fertilized eggs develop until they are much like the parent fish. Then the young are born alive, and swim about in the aquarium.

SNAKES

Snakes are animals found in many parts of the world. If you have ever taken a hike through the woods or across the fields, you have probably seen a snake. There are many different kinds of snakes. Some of them live near small streams. Others live near forests.

Some snakes may grow to be very large. Others always remain quite small. In the tropical jungles there are snakes many feet in length. Some of them, like the python and the boa constrictor, climb trees. They are colored in such a way that it is hard to see them. When they are hungry, they wait until an animal comes along. Then they leap upon it and coil themselves around it. They draw the coils very tightly, and soon the animal is crushed. Then they swallow it just as it is. Some of these huge snakes feed only about once a month.

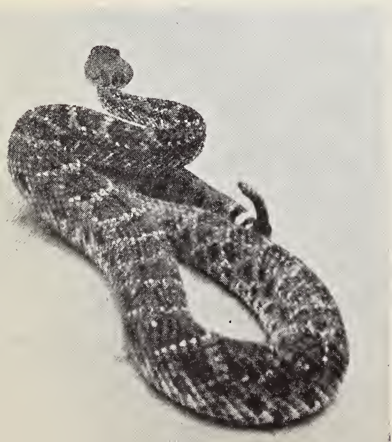
In our country we do not find snakes so large as that. Our most common snake, which you have all probably seen, is the garter snake. It is found in many of our states. If you live in the country, you will often see garter snakes in your garden. They have three yellow

stripes down the back. This snake is quite harmless. It eats insects, young toads, and young mice. If you come near it, it will try to get away as quickly as it can. It is afraid of you.

Many boys and girls are very much afraid of snakes. This is because some snakes are poisonous. Poisonous snakes usually have heads shaped like this △. They have blunt tails. Poisonous snakes do not sting. They have two fangs, or long hollow teeth, on the upper jaw of the mouth. When they are disturbed and cannot get away, they strike. A poison is put into the blood of the victim through the fangs. Sometimes this poison causes death.

Rattlesnakes are the most famous of poisonous snakes in North America. They are quite common in Texas and other southwestern states. However, they are found also in many other parts of the United States, both north and south, and in southern Canada.

This rattlesnake is poisonous. Do you see the "rattle" on the tail?



A rattlesnake has a "rattle" on its tail. When the snake is disturbed, the tail moves rapidly, causing a buzzing sound. That is why the animal is called a rattlesnake.

There are other kinds of poisonous snakes in North America. One of the best known is the copperhead. Another kind is the water

moccasin. Still another is the coral snake. All these are dangerous. They will not bite you unless you disturb them. If you see one, you should quickly and quietly move away from it.

Many snakes are useful to us. They hunt mice and eat them. You know that mice cause much damage to our crops and food supply. Some snakes eat grasshoppers and other insects that feed on our crops.

It is true that some snakes eat young birds and bird eggs. But on the whole, they do much more good than harm. You should never kill a snake unless you know that it is a poisonous one.

Have you ever picked up a garter snake? If you have, you must have noticed that it is a cold-blooded animal, like a fish. Its body feels cool.

Perhaps you have seen a very young snake. Sometimes you can find young snakes when they are not much more than six inches long. Perhaps you have even found snakes' eggs. If you could see inside one, you would see a very small snake coiled up in it. You know that the female snake must have laid the egg.

Snakes produce their young in much the same way as fishes do. Within the body of the female are ovaries, which produce the egg. This is true of female fishes too, you will remember. The female fish laid her eggs in the water, and then the male fish deposited a liquid called milt on them. Milt contained the sperm cells which fertilized the eggs.

Snake eggs, however, are fertilized in a different way. They are fertilized within the body of the female. The

Ditmars, from American Museum of Natural History

Some snakes have many young. These young water snakes were born alive

sperms are deposited within the body of the female snake. There the sperms combine with the eggs. Then a shell is made around each egg while it is still in the body of the female. After the shell has been made around the fertilized egg, the egg is laid. The shell is not like the shell of a bird's egg. It is leathery and not easily broken.

Within this shell the fertilized egg begins to divide. In this way it is like all other fertilized eggs. It divides into two cells, then four, just as the fish egg which you read about. Soon there is a hollow ball of cells, which then grows longer.

Some of these cells make up the muscles of the snake's body. Some of them become the brain. Others make up the stomach and other parts of the body. Soon the

snake within the shell looks like its parents, except that it is very small. After a few days, if the weather has been warm, the young snake breaks through the shell and crawls out of it. It is ready to begin life. It begins to look for small insects and other food. In a year or two it grows to be as large as its parents.

You know that all living things must have food and oxygen if they are to live. This is just as true of the young snake within the egg as it is true of the older snake.

How does the young snake within the egg get its food while it is in the egg? When the egg cell is developing within the body of the female, food is deposited around it. You remember that when plant seeds are developing, food is stored in the seed. Much the same thing happens in the snake egg. After the egg has been fertilized by the sperm, the food is enclosed around it by the shell. So you see the dividing cells in the snake egg have a food supply that lasts them until they hatch.

The shell of the snake egg has very small openings in it. These are so small that you cannot see them. But they are there just the same. Air passes through these openings. In this way the young snake gets its air.

After the eggs have been laid, most female snakes pay no more attention to the young. Usually the young are left alone. For that reason the unprotected young snakes are often eaten by birds and other animals. Sometimes they are even eaten by other snakes. They must look out for themselves, for they have many enemies.

American Museum of Natural History

These young snapping turtles have just hatched from the eggs

Some snakes, like some fishes, develop within the body of the female after the eggs are fertilized by the sperm cells. They remain there until they are able to take care of themselves. The female does not develop the tough, leathery shell around them. When they have developed into young snakes, they leave the body of the female. We say that they are born then.

TURTLES AND ALLIGATORS

Other reptiles lay eggs, just as some snakes do. You have seen turtles, of course. Perhaps you even have some small ones in your school or home aquarium. Larger turtles live in ponds and streams. There are many kinds. Some kinds of turtles you must handle with care. They are snapping turtles, and may bite you.

When a turtle is on the land, it walks about with head, legs, and tail outside its shell. But at the first sign of danger, head, legs, and tail quickly disappear inside the protecting shell. Only the tip of the nose may then be seen.

Turtles lay eggs in warm, sunny places on land. Within these eggs the young turtles grow, just as in the case of the young snakes. They too have their food within the shell. After they have developed, they break the shell of the eggs and crawl out of them. Some turtles are not much bigger than a penny when they hatch.

In Florida alligators lay eggs on the banks of the stream in which they live. The young alligators develop within these eggs until they are large enough to hatch. So you see, such reptiles as turtles, snakes, and alligators all develop in much the same way.

TOADS

Toads are born in ponds. They live there while they are tadpoles. Then they grow legs and live on the land.

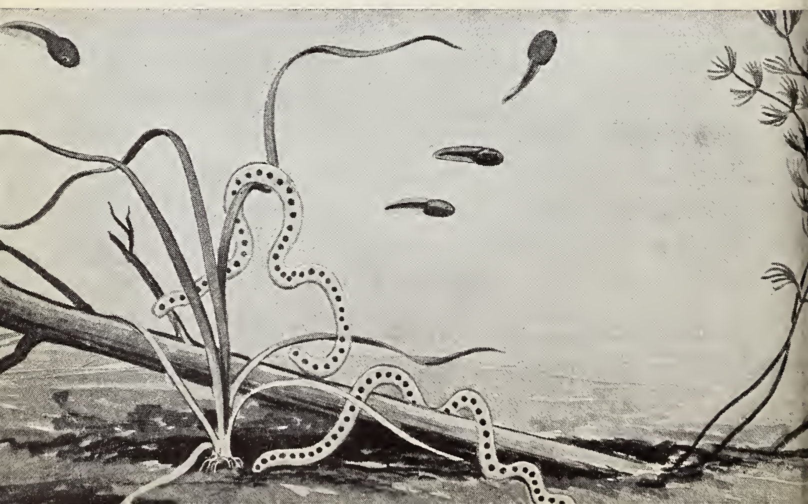
When autumn comes, toads hibernate in underground nests. Their bodies grow colder and colder. When the very coldest days come, a toad's body is just as cold as the soil around it.

When the warm spring days arrive, toads wake up. They leave their nests under the ground and hop back to the pond.

At the pond the toads find their mates. The male toads usually arrive there first. They sing and sing. Sometimes they sing all day and all night. Then the females come to lay their eggs. The eggs are covered with a liquid from the male, which fertilizes them.

Toad eggs are very small and black in color. They are usually laid in a single row in a clear, jelly-like substance. Sometimes they drop to the bottom of the

The young tadpoles were hatched from eggs. Each black dot in each row of toad's eggs may hatch into a tadpole



pond. Sometimes they are fastened to plants that grow in the water.

A mother toad swims away and leaves her eggs. She may never see the eggs or the young again. In a few days the eggs hatch. The tiny tadpoles wriggle their way out of their jelly-like covering and swim about in the water. They look and act like little fishes. One would never think they were young toads.

In order that they may live in the water like fish, little tadpoles must be able to breathe like fish. On each side of their necks there are little bunchy growths that look like fringes. These are the gills through which they breathe.

After a few days the tadpoles lose their gills and breathe through gills which are just inside a little opening. This opening is a breathing pore. As the tadpole grows bigger, its left arm comes out through this breathing pore. The right arm grows inside and then breaks through the skin when it is ready to come out.

Tadpoles are hungry, just like any other young animals in the world. They feed on tiny green plants in the water. Sometimes they may feed on one-celled animals too. You know that these small plants and animals are found in the slime on the surface of the water, on the bottom of the pond, or around larger plants in the pond.

Even though tadpoles look and act like fish, changes are going on inside and outside their bodies. For a time they seem to be nothing but heads and tails. Then the hind legs bud and begin to grow. Soon these legs are large and strong enough to be used in swimming.

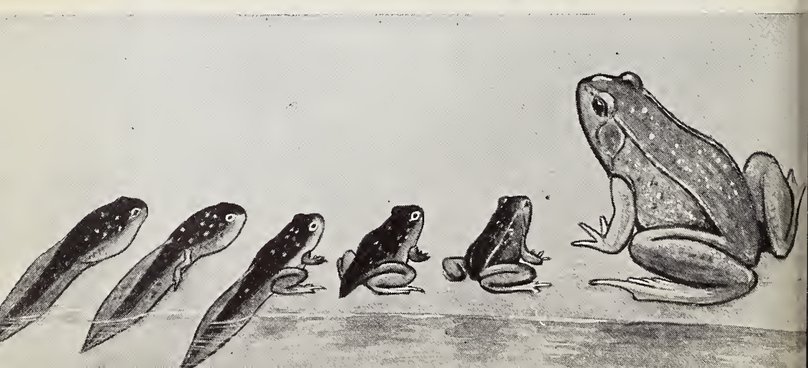
After the front legs, or arms, appear, tadpoles no longer look like fish. Their small mouths have become very large. Their eyes have grown big and seem to stand way out on their heads. Their tails grow shorter and shorter until there are no tails at all. Now the little tadpoles act differently too. They come up to the surface of the water and stick their heads out for air. They no longer breathe through gills, like fish, because lungs have formed inside their bodies. They must come up out of the water to breathe, or they would drown. Sometimes they spend most of their lives near the surface of the water.

As soon as their tails have disappeared, the wriggling tadpoles, or polliwogs, have changed to toads.

THINGS TO THINK ABOUT

1. Fish lay many eggs. The female codfish is said to lay as many as a million or more eggs in one season. If fish lay so many eggs, why are there not more fish in our lakes, ponds, and streams?

The tadpole's tail does not drop off as he grows into a frog.
It is absorbed by the young frog's body and used as food



2. Most fish seem to pay no attention to their eggs after they have been laid and fertilized, nor to their young after the eggs have been hatched. Sometimes the male fish will even eat his own young. Many other animals feed on these very young fish. The young fish are so small and helpless that they cannot defend themselves. Large numbers of them are destroyed. If the female fish did not lay many more eggs than can possibly hatch and make more fish, there would soon be no fish at all.

3. Has anyone ever told you that if you touched a toad you would have warts? This is just a silly story. A toad's body is dry and cold when you touch it. The warty-looking bumps on the skin are glands. When a toad is disturbed, a very disagreeable substance is thrown out of these glands.

4. Snakes, turtles, and alligators are reptiles, but toads and frogs belong to a class of animals known as amphibians. Amphibians spend part of their life in water and breathe oxygen from the water. Afterward their body changes so that they breathe oxygen from the air.

Do you know why some airplanes are called amphibian airplanes?

THINGS TO DO

1. It would be wise to learn to know the poisonous snakes of your part of the country. If there is a zoo near you, visit it and see these snakes. If you cannot visit a reptile house, find good pictures of snakes and study them.

When you are hiking or picnicking in a rocky country, where is the best place for you to sit and eat your lunch?

2. The life stories of toads and frogs are much alike.

Try to find some frog eggs in the spring. Frog eggs are not laid in strings, but in masses of jelly. Use the pond water in which you found the eggs to fill your aquarium. Remember that the aquarium must have plants in it. When the tadpoles begin to get legs they will need a rock so that they can climb out of the water.

Warm-blooded Animals

WHAT ARE BIRDS LIKE?

Birds are very different from fish, toads, snakes, or turtles. Birds are warm-blooded animals. This means that their blood stays at almost the same temperature all the time. If a bird is ill, it may have fever. A fever is a higher temperature than the bird usually has.

How can you tell whether an animal is a bird or not? Perhaps you think that is an easy question. Most birds can fly, you say. Yes, but many other animals can fly, too. Many insects, such as grasshoppers, flies, and mosquitoes, have wings and can fly. Bats, which are warm-blooded animals, can fly, also. One certain way to find out whether an animal is a bird or not is to see whether it has feathers.

Birds are the only animals which have feathers. All animals with feathers are birds. This means that the chickens, geese, ducks, and other animals with feathers are birds.

You know that some birds are very small. Perhaps you have seen the smallest kind of bird that lives in North America. It is the hummingbird. This little bird likes to feed on the nectar that is produced by flowers. It has a long, slender bill, which it uses to sip the nectar from the flower. The eggs of this bird are about the size of peas. Its nest is not much larger than a thimble.

Other birds are much more common. In many parts of North America, both in the cities and on the farms,

Sawders

These sea gulls have long powerful wings. These wings help them to glide above the water as they look for fish

the English sparrow is found. It is considered a pest by many people.

Crows are much larger birds, which you can recognize by their black feathers, their size, and their cawing. There are also many kinds of warblers and forest birds. Hawks are common to all parts of the country. In a

few places we find eagles. If you live near the ocean you may have seen many sea gulls and terns. Owls are very common, too.

In many places you may find quail and pheasants. You know that they make their nests on the ground. Other birds make their nests in low bushes. Many birds, like the robin, nest in trees. Woodpeckers drill a hole in a tree trunk and build their nests in the hole. Some birds build their nests in cliffs and banks along rivers and streams. The barn swallow builds its nest in a barn and lives there all summer.

Although a few birds damage our crops, most of them are very useful to the farmer. You know that they catch and eat many insects. Quail and pheasants and some kinds of field sparrows eat many weed seeds. In this way they help the farmer to kill weeds.

Owls and hawks kill and eat field mice and snakes. Some hawks have a bad reputation. Sometimes they steal baby chicks. For that reason they are often shot. Shooting hawks is not a very wise thing to do, because most hawks do far more good than harm. There are many kinds of hawks, and often the wrong kind is shot. When a farmer or hunter shoots the wrong kind of hawk, he is only harming people.

Crows too are disliked by farmers. Sometimes they pull up young corn plants when the corn is very small, and eat it.

Some birds, especially those which live near the ocean, eat clams and fish. They fly over the water until they spy a fish; then they dive into the water, seize

the fish, and fly away to eat it. Birds which eat clams have an interesting habit. The clam lives in a hard shell. When it is disturbed, it closes this shell very tightly. The bird cannot eat the clam when it is in its shell. So it carries it over a large hard rock, drops the clam on this rock, swoops down and picks it up again. Then it flies over the rock, and drops the clam on it again. It does this over and over until the clam shell is broken. Then it eats the clam inside the shell.

HOW BIRDS GROW

You know that birds build nests. Some birds, like the kildeer, do not build much of a nest. They merely gather together a few sticks and pebbles on the ground and lay their eggs in them.

The robin uses sticks and mud for the outside of its nest, and makes the inside of the nest soft with horsehair, string, and other things. The nests of orioles hang from the ends of long tree limbs. They are woven in such a way that they swing when the wind blows.

The small wren which may be near your home will build its nest almost anywhere. Wrens' nests have been found in old shoes and tin cans that have been thrown away.

After the nest has been finished, the female bird is ready to lay eggs. These eggs develop within her body. They are produced in the ovaries. Each egg is a tiny cell. These egg cells must be fertilized by sperms. The sperms are deposited within the body of the

female bird. Then the sperms find their way to the egg cells and unite with them. Each egg is thus fertilized, as you know.

The fertilized egg immediately begins to divide. Food is deposited around the fertilized egg, and then the shell is formed around it. After the shell has been formed around the egg and its food, the female bird lays the egg.

So far, you see, the egg of a bird is much like the egg of a snake. The yolk and the white of the egg are the food for the dividing cells. The young bird does not grow from the yolk and the white of the egg. It uses these as food.

If the egg of a bird is taken from the nest and kept in a cool place, the cells stop dividing. The young bird will not develop. If the egg is kept cool long enough, the cells will die. Then the egg will never hatch.

The female bird keeps the eggs warm. She does this by staying on the nest and keeping them warm with her own body. Sometimes she is fed by her mate, the male bird. Sometimes she hunts food for herself. When she does this, her mate keeps the eggs warm. If both birds leave the eggs for a long time, the developing cells in the egg will die.

As the eggs are kept warm, they develop rapidly. In a few days some of the cells in an egg have formed the heart and muscles. Other parts of the bird's body are formed by other cells.

The eggs of some birds, like the sparrow, are ready to hatch in ten days after they have been laid. Eggs of


Gendreau

Young robins are not able to hunt food.
These baby birds have not been hatched very long

larger birds need a longer time. Baby chicks will develop from hens' eggs in about twenty-one days. Goose eggs, which are larger, must be kept warm for about thirty days before they hatch. Robin eggs hatch in about two weeks.

Baby birds develop feathers within the egg. They live on the yolk and white of the egg. The white of the egg is used up first, and then the yolk.

The young bird must also breathe while it is in the egg. It gets its air through very tiny openings in the

shell, through which the air passes. When the young bird is ready to hatch, it breaks through the shell. At first it is a very wet little bird, but it soon dries.

Some baby birds are better developed than others when they hatch. Newly hatched quail and killdeer, for example, can run rapidly almost immediately after hatching. Baby chicks can soon move around and begin to hunt for food. They can feed themselves. They are covered with a soft down.

Many birds, such as robins and wrens, are very helpless when they hatch. Some of them have very few feathers and are almost naked. They can neither move nor feed themselves.

Most birds do not lay many eggs. They take care of their young very well, however. This means that most of the eggs hatch, and many of them develop into fully grown birds. If the parents did not take care of their young, the young birds would soon die.

HOW MAMMALS GROW

Birds, as you know, are warm-blooded animals with feathers. Of course there are many other kinds of warm-blooded animals besides birds. These differ from birds in one way. They are not covered with feathers. Instead, they have hair on some parts of their body.

Sometimes this hair is called fur. Sometimes it is called wool. It grows from the skin of the animal. Animals that live in cold regions usually have a thicker covering of fur than those that live in warm climates.

Mammals differ from birds in another way. They are able to produce milk with which to feed their young. The milk which you drink is produced by cows. You know that kittens feed on their mother's milk. So do young puppies. This is true of all animals which have a coat of hair. The animals which produce milk are called mammals.

In the warmer parts of North and South America there is an interesting animal called the opossum. Perhaps you have seen one. It is often hunted for its fur and is sometimes eaten by human beings. It has a trick that it uses when it is captured. It rolls over on its back and pretends to be dead. It is really only waiting for a good chance to escape. If it is chased by dogs, it climbs a tree and waits for danger to pass.

The opossum does not grow to be very large. It has a long, bare tail. Sometimes it hangs itself from a branch by this tail, just as monkeys do. Opossums are found only in the Americas.

Although opossums are hunted for their fur, there are still many in our woods. This is because they produce many young in each year.

Birds, you will remember, lay eggs from which their young hatch after having been kept warm by the female bird. Animals with hair do not lay eggs. In the body of the females are ovaries, just as there are in birds. These ovaries produce egg cells. Just as in birds, a sperm must come in contact with an egg. Then the sperm and egg unite. Only one sperm can unite with one egg.

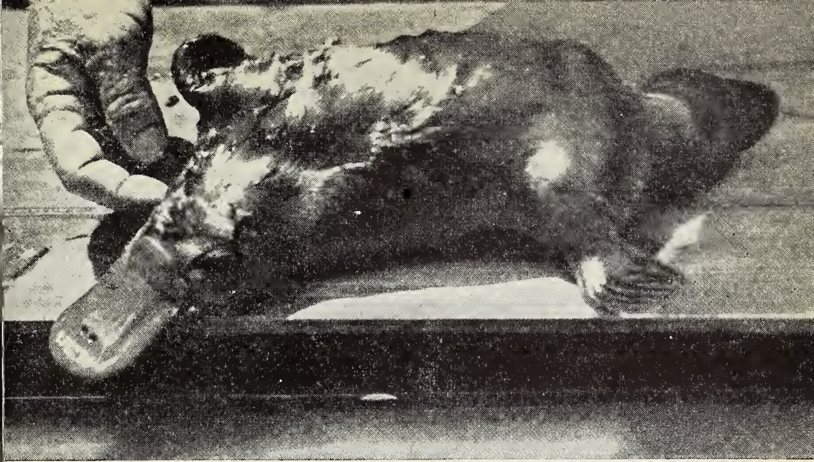
After the sperm and egg have united, the fertilized egg cell begins to divide. However, the dividing egg cell remains within the body of the female. Here it develops for some time. It soon forms a hollow ball of cells, which then becomes a long mass of cells.

Some of these cells develop into the head of the animal. Others go to make other parts of the body. The skin, heart, brain, stomach, and all the other parts of the animal's body develop from these dividing cells. The young animal which is thus formed within the body of the female is called the embryo. Soon it has its own blood supply and all the parts of the animal which produces it. It remains within the body of the female until it is well developed. When the young animal leaves the body of the mother, we say that it has been born.

In some animals, such as sheep, horses, and cows, usually only one egg is fertilized. Then only one animal is born at a time.

In many animals several eggs within the body of the mother are fertilized at the same time by the sperm cells. All of them then develop into embryo animals and are born about the same time. That is why there are several kittens in a litter. The same thing is true of puppies and young pigs.

Young opossums develop in this way. However, when they are born, they are very helpless. They crawl to the lower surface of the body of the female opossum and cling to the hair on her body. Milk is produced by the mother. It comes out through the skin to the hair



Australian National Travel Association

The duckbill is the only mammal we know about which is hatched from an egg

on her body. By sucking these hairs the young opossums feed themselves.

It is an interesting sight to see a mother opossum and her young. Usually she carries them about with her wherever she goes. As they get older, the young animals crawl to her back and hold on tightly. She is seldom seen without them. They grow larger very rapidly. Soon they learn to find food for themselves. They are usually born in the spring. By the time autumn comes they are ready to take care of themselves. Then they leave their mother.

We have said that warm-blooded animals with hair do not lay eggs. In Australia and New Zealand there is an exception to this. It is an animal that has a beak and feet much like those of birds. It is called the duckbill, for its beak is like that of a duck.

But its body is covered with hair, not feathers. However it lays eggs from which its young hatch, just as birds do. Then the young duckbill feeds on milk in much the same way as the opossum. It is a curious animal, about the size of a muskrat or cat.

Almost all warm-blooded animals with hair care for their young. You know that a female dog watches over her puppies very carefully. Sometimes she becomes very fierce if you try to play with the puppies when they are very young. She is afraid you will hurt them or carry them away.

Female rabbits make their nests in places which are hard to find. In this way they protect their young from their enemies as much as they can.

Many young animals are very helpless when they are born, and need this protection. Kittens and puppies, you know, are blind when they are born. Young mice are born without any hair on their bodies and must be kept warm. None of them can get food of their own, and so they are fed on their mother's milk.

Later they are able to eat other things brought to them by their parents. They are taken care of in this way for a long time. If they did not receive such care from their parents, they would soon die. After a while they grow large enough to be able to find their own food.

THINGS TO THINK ABOUT

1. Think about all the ways that plants and animals are alike. How are they different?

2. In what ways are all animals alike? How do they differ?

3. What things do all plants and animals need?

THINGS TO DO

1. You might like to keep some birds or mammals so as to watch their young grow up. You might have chickens and mice. What things must you know about them so that they will grow into healthy animals?

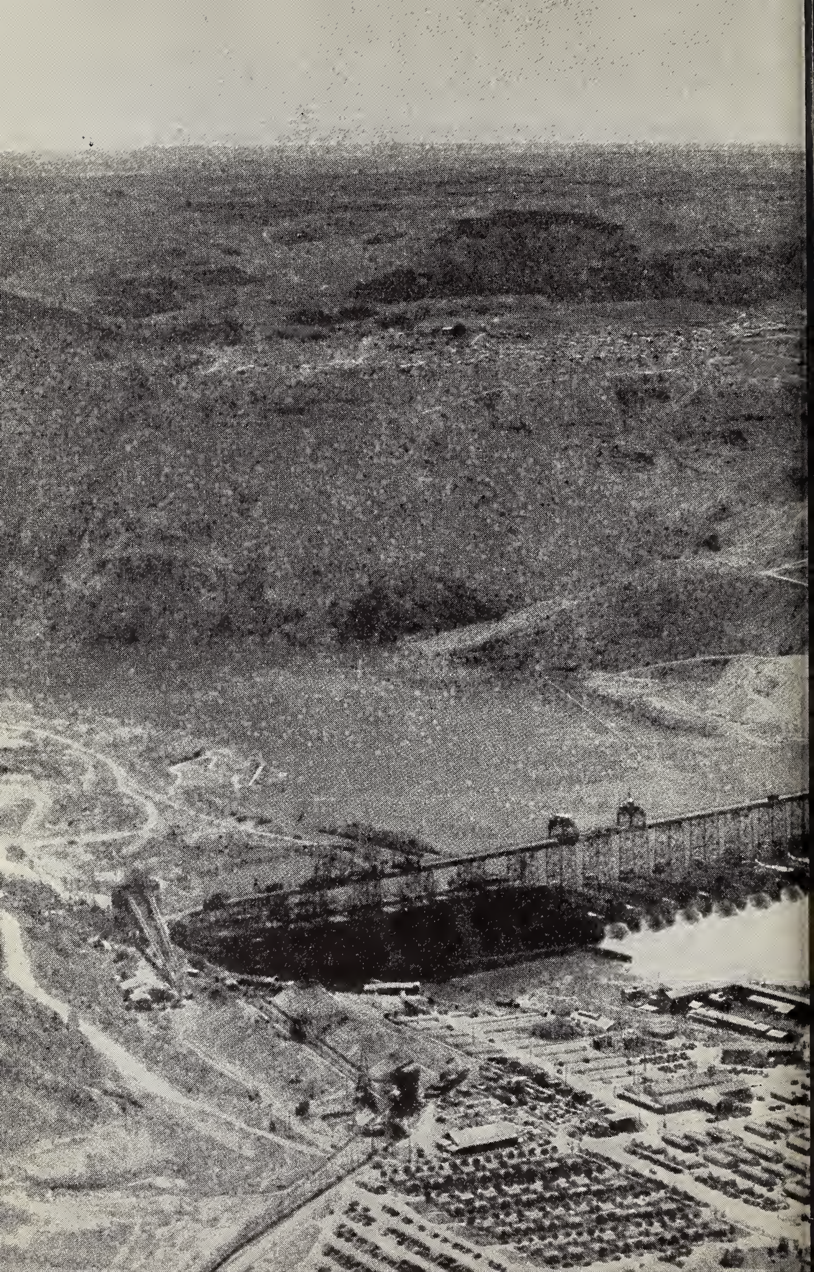
2. Find out which animals are protected by law in your state. Why is it necessary to do this?

XIII

Man and Other Living Things

MAN IS AN ANIMAL

OUR BODIES



PERHAPS you have found the study of living things interesting. There is one kind of living thing more interesting than any that you have read about so far.

You yourself are very much alive. In a great many ways you are like the other animals which you see each day. Your body is made up of many cells. The cells are made up of protoplasm, like the cells of all other living things. You can move about from one place to another.

You need food and air, and you know that all other animals must have food and air also.

You are different from other animals because you have a better brain. Man has been able to think and plan and to build great dams like the Grand Coulee Dam, which is shown in the picture on pages 398 and 399. He uses these dams to control floods, to hold water for irrigation, and to make electrical energy.

You and all other animals depend on plants for food. Of course you eat some animals, but those animals depend on plants for food.

Plants, of course, must have light energy before they can make food. So no animal and no plant that we know could go on living without heat and light energy from the sun.

THE PICTURE ON PAGES 398 AND 399 IS FROM *LIFE MAGAZINE.*

Man Is an Animal

WE ARE MAMMALS

We belong to that class of animals called mammals. Although the entire human body is not covered with hair as are the bodies of some other mammals, we do have hair on our heads. Men have hair on their faces, which they shave off. Our body temperature remains the same when we are well, showing that we are warm-blooded. Young babies are nursed on milk, just as young kittens or puppies are nursed on milk by their mothers. Human babies are born in very much the same way as the young of other mammals are.

We have bones in our bodies just as many other animals have bones. We have them in our head and arms and legs. Our ribs are bones which protect the heart and lungs from injury. We have a backbone, and there are many bones in our wrists and hands and fingers. There are many bones in our ankles, feet, and toes.

In many ways these bones are very much like those of other animals. They are made up of the same kind of materials. They have the same things to do. There are more than two hundred bones in our body. Some mammals have more bones than others.

Human beings, like other animals, depend upon plants for food. We cannot really make our own food. The farmer plants corn, wheat, oats, potatoes, and other crops. He takes care of them. These plants make sugar and starch. So we use them as food.

It is true that we also eat meat. We get pork from hogs, beef from cattle, mutton from sheep. But each of these animals feeds upon plants. Hogs are fed corn, and cattle eat grass and may be fed corn and hay. Sheep also eat grass and hay. If there were no plants, there would be no sheep or cattle or hogs. So you see that we still depend upon plants to furnish food for these animals so that we can then eat the animals.

WE ARE DIFFERENT FROM OTHER ANIMALS

In one important way we are different from all other animals. We can think much better. This is because we have a better-developed brain. We can learn things more quickly than other animals. We can write down the things which we have learned. We can learn to read. We read about things other people have done, and from them we learn how to do things ourselves. No other animal can do this. They can learn a few things, but they cannot write them down for others.

Because we have a better brain, we can make sounds mean something. We can talk to other people, tell them what we think, what we have seen, or read, or heard, or learned. By using the telephone and radio we can make our voices heard thousands of miles away from the place where we are talking. We can learn to speak in many languages, and in this way we can exchange ideas with people in other countries. No other kind of animal can do this.

We have also learned to use tools. We are the only

© Field Museum of Natural History, Restoration by Frederick Blaschke

Early men were able to make spears and train dogs
for hunting other animals for food

living things which know how to use a shovel. We make complicated automobiles, airplanes, steam shovels, and electric motors. We have learned to control energy, and to change it from one kind to another. We have learned to make light by using electricity. We use machinery to make clothes for ourselves. We build tall buildings and heat our houses. We are the only living things that can plan and change things around us to carry out that plan.

We are the only kind of living thing on earth which has learned to make use of fire. We use it to keep us warm and cook our food. We use heat energy from fire to change iron ore into iron and steel. Most animals are afraid of fire.

A long time ago, long before man knew how to read or write, he learned to make use of other living things which he found all around him. He discovered that if he captured certain animals when they were very young, they would become tame and would not leave him, that they then depended upon him for their food. In this way he probably learned how to keep and use dogs, horses, cattle, sheep, pigs, chickens, ducks, turkeys, cats, and other domesticated animals. You will remember that when the first white men came to America there were no horses in this country. A few horses escaped from the Spaniards who were exploring the southwestern part of the United States. These horses roamed the prairies and reproduced rapidly. Soon there were a great many wild horses in the western states. The Indians learned to capture them, tame them, and ride them.

Some animals which man domesticated were found to be a good source of meat. It was much easier to kill a domesticated animal and eat it than to hunt a wild animal. For that reason man soon began keeping enough animals to furnish him with meat whenever he needed it. He used the skins and hides to make clothes for himself. When a calf was born, he learned that the cow produced milk; so he killed the calf, ate it, milked the cow, and drank the milk himself.

In the wintertime a great many of the animals died if the snow was deep and the weather cold. So man learned to cut grass and dry it, storing it for use in the wintertime. Then he learned that if he gathered the seeds of the grasses and other plants, he could plant these in the spring and they would grow. Thus man learned to farm. Some of the crops he raised for his own use, and some he fed to his animals. It took man thousands of years to learn all these things.

Since man had a better brain than other animals, he was always trying new ideas. He decided that it would be easier for him if he could get his animals to do his work for him. Later he used oxen to do much of his farm work. If he wanted to go from one place to another, it was easier to ride a horse or camel or donkey than it was to walk. He trained his dogs to follow the trail of wild animals that he wished to kill, and thus had help in hunting.

All these things were learned thousands of years ago. But even today we are very dependent upon our domesticated animals. Not being able to make our own food,

we still grow plants and let them make it for us. We still depend upon the animals we have learned to control for our meat supply. Millions of farmers all over the world spend their whole lives furnishing man with food.

Not only have we learned much about how to control animals, but we have learned to make good use of plants too. Almost all the plants which we now grow were once wild. Wheat was probably one of the first crops man grew. In some parts of the world wild wheat still grows. Rice, sugar cane, potatoes, rye, corn, and barley are just a few of the important ones. You could easily make a very long list of the different kinds of plants we use for food.

THINGS TO THINK ABOUT

1. Think of what a queer world this would be if we were the only animals on it!

What kind of food would you eat? What kind of clothing would you wear? How would you have to travel about?

2. Scientists are always working to improve animals and plants. By crossing certain kinds of plants, new plants are grown. This is also true of animals.

Read about Burbank's experiments with growing new kinds of plants.

Newspapers often print stories of the types of plants and animals that scientists are interested in growing.

Our Bodies

FOOD FOR OUR BODIES

Let us stop to think about some of the many things you do each day. When you get up in the morning you bathe, dress, eat breakfast, and probably walk to school. While you are in school you study, go to classes, and take part in schoolwork. When recess time comes, you probably go out on the school grounds and play games. Then you go back to your classes until noon.

When it is noon, you probably go home for lunch. Most of you walk home, and then walk back to school again. When school is over, you walk home again. At home you probably play games or go for a walk. Or perhaps you run errands for your mother. Then it is time for your supper. After supper you may study for a while or visit some friends. Then you go to bed.

If you have done all these things, you have had a busy day. You have done much walking, running, playing, and some work. What makes it possible for you to do all these things?

You have often been told that in order to grow strong and large you must eat at each mealtime the food your mother prepares for you. Perhaps you realize that the strength you have comes from the foods you eat. In order to move, work, play, and study, you must have energy.

You know that there are many kinds of food. At different meals you have probably eaten several kinds of

meat. You may also have had milk, bread, sugar, cheese, eggs, spinach, and fruit. You may have had potatoes, cake, candy. You probably have something different each meal.

It is a good thing to eat many different kinds of food. Each kind of food furnishes the body with something it needs.

Foods contain food substances. Bread, cake, and potatoes contain large quantities of a food substance called carbohydrate. This food substance is used in your body for heat energy. There are two main kinds of carbohydrates. Sugar is one of them, and the other is starch. There are many kinds of sugars. The kind you use to sweeten your foods is probably made from sugar cane, or sugar beets. There are also many kinds of starches found in different kinds of food.

Meat, fish, eggs, beans, and peas contain a food substance called protein. Carbohydrates furnish your body with heat energy. Proteins are necessary to build up new cells in your body, so that you can grow properly.

Fats are another kind of food substance necessary to give you heat energy and to help you to grow. Butter is one kind of fat we often eat. Almost all meat has some fat in it.

While you are growing, your body needs material with which to build bones and teeth. As you know, bones and teeth are hard and so are different from skin or muscles. In order to form good, strong bones and healthy teeth, you must have minerals. Calcium is the mineral which is needed to build bones and teeth. Milk

is an excellent source of calcium and other minerals. For this reason you should drink plenty of milk.

Other foods also contain minerals. Fresh, leafy vegetables and fresh fruits contain minerals that your body can use. You should eat both often, so that your teeth and bones will be strong and healthy. Sea foods, such as fish, lobsters, and oysters are good sources of minerals.

There is still another thing your body must have to develop and grow. Almost all the fresh foods you eat contain vitamins. Without vitamins many things go

This girl is eating a well-balanced meal. Can you tell how many different kinds of food substances there are in this meal?

Doris Day

wrong with the body. The bones do not develop as they should, and several kinds of diseases may result. Milk, fresh fruits, fresh meat, and all leafy vegetables contain vitamins which you need.

Many boys and girls think that they do not like some kinds of foods. For that reason some of them will not eat vegetables, while others do not like to drink milk. However, their bodies need all the different kinds of food substances and if they do not eat some of each kind of food, they may not be getting the right amount of the different food substances. When this happens, their teeth and bones do not develop properly, and they may have diseases which other children do not have.

HOW FOOD IS DIGESTED

What happens to the foods you eat? You may be surprised to know that the milk you drink or the meat you have for dinner must be changed a great deal before you can get energy from it.

First of all, most of the food we eat must be cooked. Raw meat, for example, might give you a stomach-ache. It must be cooked, so that it can be used by your body. The food is softened and changed, so that it can be digested more easily. Bread must be baked, and many vegetables are much better for you if they are cooked. Raw potatoes, for example, would not do you much good. You see that even before we eat food, we must begin to change it by cooking it. Cooking also improves the flavor of many foods. Some foods, like certain vege-

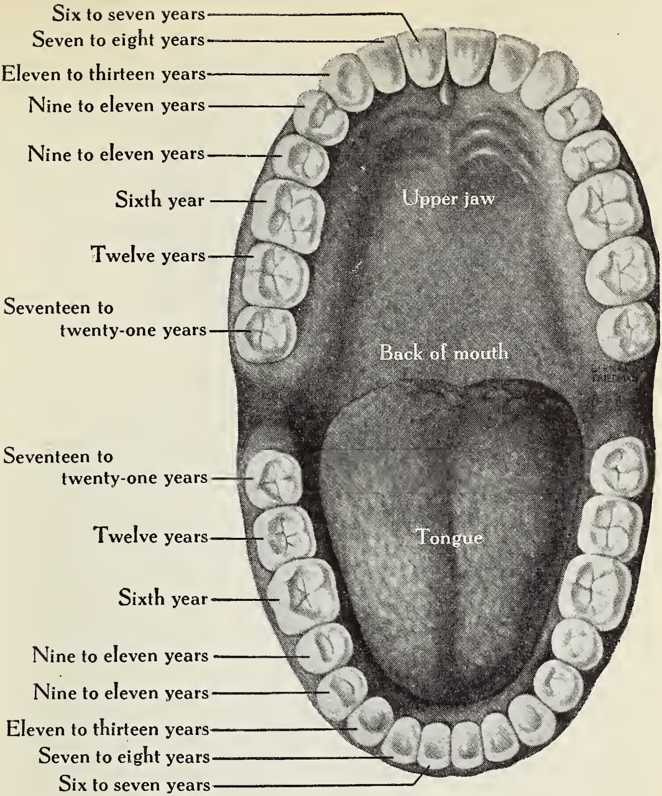
tables, fruits, and milk, are better for us when they are eaten without being cooked.

When you eat, you bring about many other changes in the food. First of all, you chew it. This is important for several reasons. By chewing the food you break it up into very small particles.

In order to chew your food well you must have good teeth. You know that a very young baby has no teeth. As the baby becomes older, the teeth come through the gums. The first tooth appears in the front part of the mouth, and soon after others appear. This first set of teeth are called temporary teeth, or teeth lasting only a while, because as the child grows older these fall out and are replaced by others. There are twenty temporary teeth altogether. If you examine your own teeth, you will probably find that most of the temporary ones are gone. They are being replaced by your permanent teeth.

When you grow up you will find that you have thirty-two teeth, sixteen in the upper jaw and an equal number in the lower jaw. If you examine your teeth before a mirror, you will find that in each jaw, in the front of the mouth, you have four rather broad and sharp teeth. These are called incisors. They are the teeth you use in biting, as when you are biting into an apple. On each side of the incisors in each jaw, you will notice a longer and more pointed tooth, that is, four in all. These four longer and more pointed teeth are called canine teeth.

Back from the canine teeth you will find others that are quite different. The top of these are not sharp, but blunt. These teeth are used to grind your food.



This is a full set of permanent teeth. How many permanent teeth are you supposed to have?[1]

The outer part of each tooth is made up of a very hard substance called enamel. Underneath the enamel is a softer substance, called dentine. Inside the tooth is a tube which carries blood to the tooth. A nerve is also found there. When there is something wrong with a tooth this nerve aches.

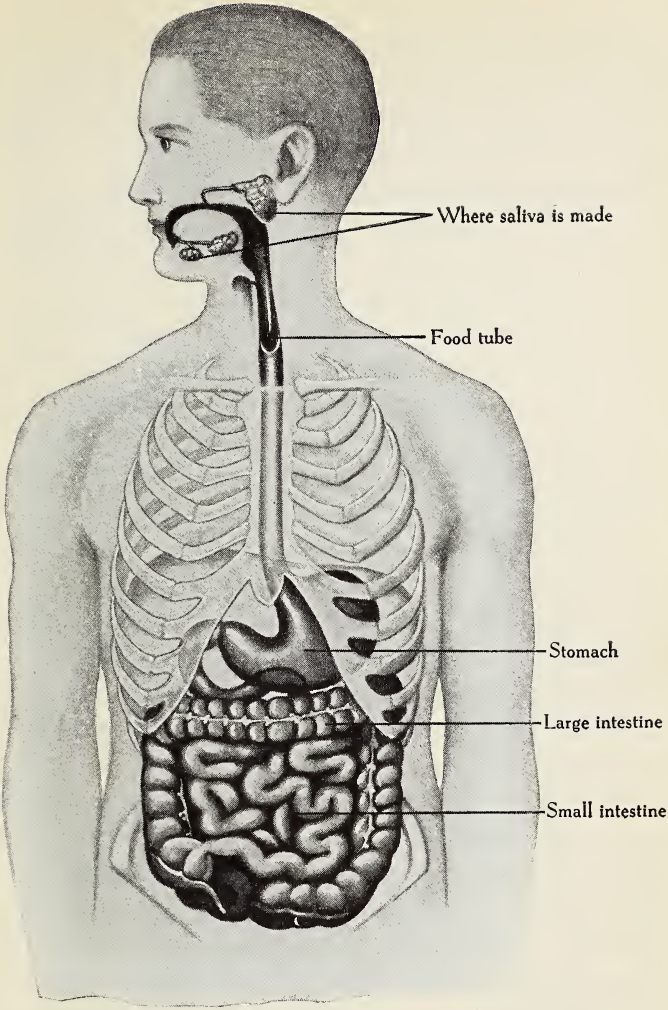
[1]From Andress-Goldberger-Hallock, *Building Good Health.*

If your body is to make good use of your food, the food must be well chewed. To chew food well, you must have good teeth. One way to have good teeth is to eat plenty of food which contains minerals, such as milk. Keeping the teeth clean by brushing them often also helps to prevent tooth decay, and thus keeps the teeth strong.

Often teeth develop holes so small that you do not know they are there. Food often gets into these holes, and bacteria act on the food in such a way as to produce a substance called an acid. Acid causes teeth to decay, so that often a tooth must be taken out of the gum if a hole in the tooth is not filled in time. Since permanent teeth are not replaced, to have a permanent tooth pulled means to have one tooth less. It is important, therefore, that you go to a dentist twice a year to have your teeth checked. The dentist can clean and repair your teeth so that they will last longer.

Several things happen to food while it is being chewed. Your teeth break it up into smaller particles so that it is easier to swallow. Inside your mouth are a number of glands which produce a liquid called saliva. It is the saliva that causes your mouth to "water" when you see food you would like very much to eat. The food is mixed with saliva and moistened. This also makes it easier to swallow. If you try to swallow a dry, unchewed piece of soda cracker, you will learn how important saliva is.

Saliva contains a substance known as an enzyme. Enzymes are necessary to change foods so that your body can use them. The enzyme in the saliva changes



Can you trace the path of food through the body?

[1]From Andress-Goldberger-Dolch, *Growing Big and Strong*

starch in the foods you eat into sugar. Your body can use sugar, but it cannot use starch until it is changed to sugar. For this reason it is necessary to chew food very well. In this way it becomes mixed with saliva, so that the enzyme in it can change the starch to sugar.

After the food has been well chewed, it is swallowed. It passes to the back of the mouth into a moist tube which leads down into the stomach.

The stomach is somewhat pear-shaped and is made up of a special kind of muscle. At that end where the food will leave after the stomach has done its work on it is a strong round muscle. This muscle contracts and closes the opening of the stomach, so that the food remains in it for a time.

As the food enters, the stomach begins to act upon it. The muscles in its walls begin to contract in such a way that the food is broken down into very fine particles. In the walls of the stomach there are glands which produce enzymes that help to change the food into a liquid. Hydrochloric acid is also produced in the stomach. It too helps to change the food into a liquid.

When the food has been acted upon by the stomach, the round muscle at its end relaxes and lets the food pass on. It goes into the small intestine, where the process of changing foods to a liquid is completed. Near the stomach we find the liver and the pancreas. Both the liver and the pancreas produce juices which are emptied into the small intestine to help in finishing digestion. In the walls of the small intestine, glands produce intestinal juice, which also helps in the digestion of foods.

By this time much of the food you have eaten is changed to a liquid. In the walls of the small intestine there are many very tiny projections, called villi (singular, villus). Inside the villi there are many very small blood vessels. The liquid food material passes into these blood vessels through the villi and is carried away by the blood.

Much of the food you eat is not changed into liquid form. It passes on through the small intestine and goes into the large intestine. From the large intestine the material passes out of your body.

The food which you have eaten and which has been changed from a solid to a liquid now begins its journey through your body. It must be carried by the blood to all parts of your body. It must go to the cells in your skin and in your muscles. The cells in your brain need material from the food you eat. The blood, therefore, must carry the liquid, digested foods to every part of you. If the cells did not get food, they would die. That is what happens when people starve to death.

THE WORK OF THE BLOOD

Blood, you know, is a very important part of you. You have seen it when you have cut yourself. It is a liquid. Our blood has a very important task to do.

About 90 per cent of the blood is water. In this water there are many things. If you were to look at a drop of blood through a microscope, you would see in it a great many round, flat objects. If you saw a mass of these to-

gether, they would appear to be red in color. But if you saw just one, it would not be red at all. It would be a pale yellow, like straw. These objects in the blood are called red corpuscles. There are many millions of them in your blood. They are cells. The corpuscles are made in the hollow parts of your bones.

With your microscope you would also see another kind of corpuscles moving about within the blood, known as white corpuscles. The white corpuscles help to overcome certain diseases which we may have.

Chemists find other things in the blood. Sugar in very small amounts is always present, and so is calcium, and ordinary salt. The blood contains many things.

Food furnishes our body with energy. Each cell gets energy from the food which has been changed to a liquid form by digestion. But to get this energy, the food must be slowly burned in the cells. This seems very hard to believe. You probably think that if there is fire in our bodies we would burn up. This is true. But the food that is burned in our bodies is burned so slowly and in such small quantities that it is not enough to burn up our body. It is the energy from the food burned in the cells that keeps our body warm.

Perhaps you are wondering how a liquid like the food in our bodies can burn. It does not burn so quickly as wood or coal burns, but it burns in much the same way. Any burning is just a chemical change. When anything combines with oxygen, it is burned.

In the body, food in liquid form combines with the oxygen you breathe in. Heat energy is given off.

How does oxygen get to the cells so that it may combine with food to give off energy? It is brought to the cells by the red blood corpuscles. The oxygen combines with food in the cell, and heat energy is given off.

As you know, whenever wood burns, smoke and ashes are made. They are the waste products of burning. When food is burned in the cells, waste products are formed. Carbon dioxide is one of them. There are no ashes, but there are liquid wastes. The red corpuscles in the blood also carry the carbon dioxide away from the cells.

Thus you see that the blood carries food and oxygen to the cells. After the food has been burned, and waste materials are formed, the blood carries the carbon dioxide and the other waste materials away from the cells.

THE WORK OF THE HEART

In order to do its work properly, the blood must be kept moving. It passes through a system of tubes in the body. It is kept moving by the heart, which acts as a sort of pump. All the blood in your body is contained in the tubes, and all of it passes through the heart.

Your heart is almost in the center of your chest beneath the ribs. It is made up of muscles, which keep the blood moving through your body.

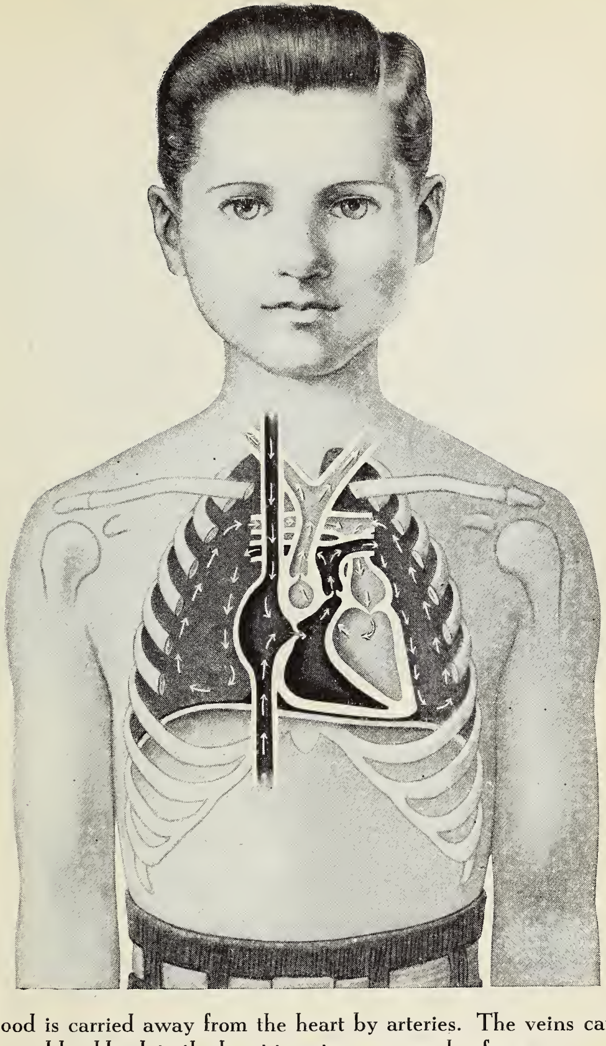
The blood tubes in your body are of two kinds. One kind carries the blood away from the heart. Tubes of this kind are called arteries. The other kind carries the blood back toward the heart. These are called veins.

Arteries carry the blood away from the heart to every part of the body. This makes it possible for the blood to carry food and oxygen to all the cells. The arteries close to the heart are large; but they keep branching off, so that those found farthest from the heart are very small. The ends of these small arteries are very fine tubes, called capillaries.

The capillaries carry blood from the arteries to the veins. The veins take the blood back to the heart. They too are branched, and are largest near the heart.

When you breathe, you are causing air to go into your lungs. As you know, the air which you breathe contains oxygen. So when you breathe air into your lungs, you are breathing in oxygen. The artery which leads from the heart to the lungs branches off until it forms a network of very fine capillaries. The blood takes in the oxygen from the air in your lungs. At the same time, it gives up the carbon dioxide which it contains. You remember that this carbon dioxide came from the cells where food was burned.

After the blood has taken in oxygen and given up its carbon dioxide, it passes through the heart. It passes out through an artery which leads away from the heart. This artery branches off into other arteries. Some of these go to the head to furnish the face and brain with food and oxygen. Others branch off into the arms. Still others branch off into the legs. In this way every living cell of your body gets a supply of food and oxygen from the blood.



Blood is carried away from the heart by arteries. The veins carry blood back to the heart to get a new supply of oxygen

Galloway

These boys use a great deal of energy,
so they must eat plenty of energy-giving foods

OUR BODIES ARE VERY COMPLICATED

Perhaps you are beginning to understand what a complicated thing your body is. It is made up of protoplasm. The protoplasm is organized into cells. There are billions of cells in each human being. Some of them are muscle cells. Some are skin cells. Some make up bones.

All the living cells in your body must have energy. You eat food to furnish the energy. The food must be changed into a liquid state by digestion. It then enters the blood through the villi of the small intestine and is carried to the cells. In the lungs the blood picks up oxygen, carries it to the cells, and takes away the liquid wastes and carbon dioxide.

In the cells the food and oxygen combine. Energy is given off. The cells use this energy to carry on their work. Some of the food they use for growth, and some may be stored as fat in the body for future use. Liquid wastes are carried away by the blood. Indigestible foods pass from the small intestine into the large intestine. From there they pass out of the body.

The human body is a very complicated thing. It needs and deserves good care. If we eat the proper foods, get plenty of rest, breathe fresh air, and get enough exercise, our bodies will probably remain in good condition for a long time. If we do not treat our body properly, it may fail us.

THINGS TO THINK ABOUT

Can you think of the different kinds of energy that are used on the earth?

Energy is used for light and heat. Animals use energy for moving. Machines are moved by energy. Plants must have energy to make food. Animals use this food for energy. We depend on plants and other animals for energy to be used in our bodies.

But now you know that this energy used on the earth really comes from the sun.

Science Words

This list of science words and explanations may be used as a dictionary to help you in studying the problems suggested in this book. When you come to a new word, find the explanation of the word. It will help you to understand what you are reading.

The explanations for the words given in this book will not tell everything about the words that might be told. The authors have tried to give the kind of information that they think will be most helpful to you now. In your later science work you will learn a great deal more about some of these words.

Some of these words you will find are very useful. You will want to learn to use them. See how many of these words you can use at home and at school.

Following the explanation you will find the number of the page where the word is first used in the book. In the index you may find the numbers of the other pages on which the word is used.

KEY TO THE SOUNDS

ă *as in* at	ē *as in* be	ō *as in* go	ū *as in* use
ā *as in* ate	ẽ *as in* her	ô *as in* horse	ŋ *as in* ink
ä *as in* arm	ĭ *as in* bit	oi *as in* oil	th *as in* bathe
â *as in* care	ī *as in* bite	o͞o *as in* food	zh *like the* s *in* pleasure
ĕ *as in* bet	ŏ *as in* got	ŭ *as in* us	

Absorb (ăb sôrb′). To take up or hold as a blotter takes up ink (p. 31)

Acid (ăs′ĭd). A class of chemicals which taste sour. Lemon juice contains an acid (p. 414)

Air pressure. Air is so light that it does not seem to weigh anything. Yet all the air does weigh something and it presses on us. This pressing is air pressure (p. 186)

Anther. The part of a stamen in a flower which makes pollen (p. 342)

Anthracite (ăn′thra sīt). A hard coal which burns slowly (p. 303)

Aquarium (a kwâr'ĭ um). A tank in which to keep water plants and animals (p. 18)

Artery. One of the tubes which carry the blood *from* the heart to all parts of the body (p. 419)

Asteroid (ăs'tẽr oid). One of many tiny planets revolving around the sun between the paths of Mars and Jupiter (p. 265)

Astronomer (as trŏn'ō mẽr). A scientist who studies the universe (p. 269)

Atmosphere (ăt'mos fēr). The layer of gases around the earth (p. 28)

Aurora borealis (ô rō'ra bō rē ā'lĭs). The scientists' name for the northern lights (p. 247)

Axis (ăk'sĭs). The imaginary straight line from the north pole to the south pole through the center of the earth. The earth rotates upon its axis (p. 43)

Bacteria (băk tēr'ĭ a). One-celled plants so small that they can be seen only with a microscope (p. 323)

Barometer (ba rŏm'ē tẽr). An instrument which measures air pressure (p. 203)

Burrow (bẽr'ō). A hole dug by some kinds of small animals to live in (p. 106)

Capillary (kăp'i lĕr ĭ). One of the smallest tubes which carry blood in the body (p. 420)

Carbohydrates (kär bō hī'drāts). Foods which are chiefly used to give the body strength and warmth. Sugar, bread, and potatoes are carbohydrates (p. 409)

Caterpillar. *See* Larva

Cell. Every living thing is made of one or more cells (p. 321)

Charge. An amount of electricity. A charge may be positive or negative electricity (p. 194)

Chemical (kĕm'ĭ kal). All substances are made of chemicals. Iron, lime, sulfur, alcohol, and salt are chemicals (p. 12)

Chemical energy. Some chemicals have the power to produce heat or light energy when they act on other chemicals. This power is called chemical energy (p. 240)

Chlorophyll (klō'rō fĭl). The green coloring matter in plants (p. 323)

Chrysalis (krĭs'a lĭs). *See* Pupa

Circuit (sẽr'kĭt). A path for electricity (p. 232)

Climate. The average condition of the weather at a place (p. 119)

Cocoon (ko kōōn′). The silky shell, or case, spun by the caterpillars of some insects (p. 64)

Cold-blooded animals. Animals whose blood is about the same temperature as their surroundings. Snakes, turtles, and fish are cold-blooded animals (p. 103)

Comet. Comets are members of the solar system. They travel around the sun in an oval-shaped path. We do not know exactly what they are made of (p. 253)

Compass (kŭm′pas). A magnetic instrument used to tell directions (p. 73)

Condense (kon dĕns′). To combine in a smaller space (p. 187)

Conductor of electricity. Something that can carry electricity. Copper wire is a conductor (p. 35)

Conservation (kŏn sẽr vā′shun). The use of natural resources in a wise, not wasteful, manner (p. 299)

Constellation (kŏn ste lā′shun). Any group of stars in the sky which seemed to ancient peoples to be the figure of some animal, god, or hero (p. 255)

Corpuscle (kôr′pŭs'l). A cell which floats freely in the blood. There are both red and white corpuscles (p. 418)

Cyclone (sī′klōn). An area of low air pressure which may be many miles in width (p. 189)

Deciduous (dē sĭd′ū us) *trees.* Trees which drop their leaves in the fall. Deciduous trees do not die in the fall (p. 58)

Dentine (dĕn′tēn). The hard part of a tooth under the enamel. Dentine contains much calcium (p. 413)

Desert (dĕz′ẽrt). A region of the earth where there is very little plant life. Few plants grow in deserts because there is not enough water (p. 119)

Digestion. The dissolving and breaking down of food by certain chemicals in the body (p. 418)

Disease. Illness or sickness. Colds and chicken pox are diseases (p. 172)

Electric current. Electricity passing through a conductor, such as iron or copper (p. 226)

Electricity. A movement of electrons (pp. 6, 194)

Electromagnet (ē lĕk trō măg′nĕt). A magnet made by winding an

insulated wire around a piece of soft iron. When electricity goes through the wire the iron becomes a magnet (p. 226)

Electrons (ē lĕk′trŏnz). The negative charges of electricity in atoms (p. 232)

Enamel (ĕn ăm′el). The very hard outer layer of a tooth. Enamel protects the tooth (p. 413)

Energy (ĕn′ẽr jĭ). The power to *do* something. Heat and light are forms of energy (p. 10)

Enzymes (ĕn′zīmz). Substances produced in the body which help to digest food (p. 414)

Evaporate. When liquids, such as water and gasoline, change into a gas, they are said to evaporate (p. 27)

Expand. To get larger (p. 187)

Experiment. A trial made to prove or disprove something (p. 46)

Fat (food). Any food consisting chiefly of oil or grease (p. 409)

Fertilization (fẽr ti lĭ zā′shun). The union of a female and a male germ cell to form a new plant or animal (p. 343)

Freeze. When liquids, such as water or melted lead, change into a solid, they are said to freeze (p. 190)

Friction (frĭk′shun). Resistance to rubbing or sliding. The smoother the surface, the less the friction (p. 242)

Frictional electricity. Electricity produced by friction between certain nonconductors (p. 242)

Galaxy (găl′ak sĭ). A group of stars forming a system in the universe. The Milky Way is a galaxy (p. 292)

Gas. The state of a substance in which it holds no definite shape or volume of its own. Air is made up of such gases as oxygen, carbon dioxide, nitrogen, and water vapor (p. 185)

Generator (jĕn′ẽr ā tẽr). A machine by which mechanical energy is changed to electrical energy (p. 251)

Germ (jẽrm). Any disease-producing plant or animal which can be seen only with a microscope (p. 59)

Glacier (glā′shẽr). A great sheet of ice which moves very slowly over land (p. 134)

Gland. A part of the body which produces a liquid used in the body. Saliva is produced by the salivary glands (p. 414)

Gravitation (grăv i tā′shun). The attraction of any two bodies for each other. Gravitation holds the moon in its orbit (p. 266)

High-pressure area. A place where the air pressure is highest (p.189)
Humidity (hū mĭd′i tĭ). Moisture or dampness of the air (p. 200)
Humus (hū′mus). Decayed plant or animal material found in the soil (p. 351)

Insect. A small animal whose body is divided into three parts. All insects have six legs (p. 63)
Insulator (ĭn′sū la tẽr). Any material which will not allow electricity, heat, or sound to pass through it. An insulator is a nonconductor (p. 234)

Larva. The wormlike form in which certain insects hatch from the egg and in which they remain until they form a chrysalis, or cocoon. A caterpillar is a larva (p. 66)
Leaf scar. A mark left on a stem after a leaf has fallen (p. 58)
Light year. The distance light travels in one year. Light travels nearly six million million miles in one year (p. 262)
Liquid. The state of a substance in which it holds no definite shape but does hold a definite volume. Water, oil, gasoline, and melted lead are liquids (p. 38)
Loadstone. A magnetic rock (p. 212)
Low-pressure area. A place where the air pressure is lowest (p. 189)

Magnet. A piece of iron or steel which has the power to attract iron or steel. Some magnets are made by man. Some occur naturally, such as the iron ore called loadstone (p. 212)
Magnitude (măg′ni tūd). Stars are classed according to their brightness. The classes are called magnitudes. The brightest stars are said to be of the first magnitude (p. 255)
Mammal. Any animal whose young is fed milk from its mother (p. 390)
Mechanical energy. The power to do something by movement (p. 240)
Metamorphosis (mĕt a môr′fō sĭs). A great change in the form of an animal after hatching. When a tadpole has changed to a frog we say it has gone through a metamorphosis (p. 66)
Meteor (mē′tē ẽr). Shooting stars are meteors. Meteors are small mineral bodies moving about in the solar system (p. 277)
Meteorite (mē′tē ẽr īt). A meteor which has come to rest on the solid part of the earth (p. 279)

Microscope (mī'krō skōp). An instrument which makes a very small object look big (p. 32)

Migration (mī grā'shun). To travel at regular times from one place to another (p. 73)

Milt. The liquid that fertilizes fish eggs (p. 372)

Mineral. Nonliving chemical substances, such as iron, sulfur, quartz, and calcium. Rocks are made of minerals (p. 410)

Mold. A small plant which usually grows on decaying plant material (p. 328)

Molecule (mŏl'ē kūl). The smallest complete part of any substance (p. 32)

Muscle (mŭs''l). A part of the body which is used to produce motion in the body (p. 416)

Nebula (nĕb'ū la). A huge cloud of gas far out in space (p. 293)

Nectar (nĕk'tẽr). A sweet liquid produced in the flower of a plant (p. 113)

Nerve. A cordlike part of the body which carries messages through the body (p. 413)

Oasis (ō ā'sĭs). A place in a desert where there is enough water for trees and other plants to grow (p. 153)

Opaque (ō pāk'). When light cannot pass through an object, we say that it is opaque (p. 24)

Ovary (ō'va rĭ). The part of a plant or animal in which egg cells are produced (p. 387)

Phases (fā'zĭz) *of moon.* The regular monthly changes in the appearance of the moon (p. 287)

Photosynthesis (fō tō sĭn'thē sĭs). Putting together of water, carbon dioxide, and some minerals with the aid of sunlight to make food in a plant (p. 324)

Pistil. The part of a plant through which the pollen which falls on it fertilizes the egg cells (p. 342)

Planet. A heavenly body which revolves around the sun. We live on one of the planets (p. 265)

Pollen. The yellow dust produced by flowering plants, which contains sperm cells (p. 113)

Prism (prĭz''m). A transparent object which separates light into its different wave lengths, or colors (p. 17)

Proteins (prō′tē ĭnz). Foods which are chiefly used for growth and repair of the body. Meats and cheeses are protein food (p. 409)

Protons (prō′tŏnz). The positive charges of electricity in atoms (p. 232)

Protoplasm (prō′to plăz'm). A colorless material of which all living things are made (p. 321)

Pupa (pū′pa). The form an insect has while it is in a cocoon, or chrysalis (p. 64)

Reflect. When an object throws back light which falls on it, the object is said to reflect light. You see yourself in a mirror when the light from your face is reflected in the mirror (p. 20)

Repel (rē pĕl′). To push away. The north pole of one magnet will repel the north pole of another magnet (p. 247)

Reptile (rĕp′tĭl). A cold-blooded crawling animal (p. 114)

Saliva (sa lī′va). The fluid produced by the salivary glands in the mouth. Saliva mixes with the food and helps to digest it (p. 414)

Satellite (săt′e līt). A body which revolves around a planet. Our satellite is called the moon (p. 266)

Segment. A part of anything (p. 365)

Sepal. One of the small green leaves which protects a flower bud and remains just under the petals when the flower opens (p. 342)

Separation layer. A thin layer of cells which grows between the leaf and the stem in the late summer (p. 59)

Shooting star. See Meteor

Solar system. The sun and all the bodies which revolve around it (p. 265)

Spectrum. The band of colors which sunlight makes when it is passed through a prism (p. 18)

Sperm. The cell which fertilizes an egg cell (p. 387)

Stamen (stā′men). The part of a flower which produces pollen (p. 342)

Star. A star is a sun far away in space (p. 160)

Steam. Water in the form of a gas. Steam cannot be seen (p. 251)

Stratosphere (strā′tō sfēr). A layer of thin air which begins about six miles above sea level (p. 249)

Sun spot. Spots on the sun which are not so bright as the rest of the sun (p. 262)

Telescope. An instrument which makes it possible to see far more stars and other very distant objects in the sky than we could see without it (p. 254)

Temperate. Moderate in temperature (p. 126)

Temperature. The measure of heat in anything (p. 38)

Theory (thē′ō rĭ). The best guess we can make to explain something from known facts (p. 15)

Thermometer. An instrument used to measure temperature (p. 26)

Tornado. A very strong whirling wind with a funnel-shaped cloud. A tornado is very destructive (p. 188)

Translucent (trăns lū′sent). When light can pass through an object through which we cannot see clearly, we say the object is translucent (p. 24)

Transparent (trăns pâr′ent). When we can see through an object we say the object is transparent (p. 24)

Tuber. A kind of stem that grows under the ground. The white potato is a tuber (p. 55)

Universe. The earth and all the other bodies in the sky (p. 253)

Vapor. A gas is a vapor. Steam is water vapor. Anything turns to vapor if it is hot enough (p. 13)

Vein (vān). One of the tubes which carry the blood *to* the heart from all parts of the body (p. 419)

Villi (vĭl′ī). Small projections in the small intestines which absorb food (p. 417)

Vitamin (vī′ta mĭn). Foods which are necessary in small amounts. Oranges, tomatoes, and milk contain unusual amounts of vitamins (p. 410)

Warm-blooded animals. Animals whose blood remains at a certain temperature are warm-blooded animals (p. 103)

X ray. An invisible light ray of very short wave lengths. X rays can go through solid objects (p. 15)

Zone. One of the five great divisions of the earth's surface. They are the torrid zone, two temperate zones, and two frigid zones (p. 126)

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